A sixteenth century conception of the three founders of early mediaeval anatomy, from the title-page of the *Opera Ysaac,* 1515.

ANATOMICAL TEXTS OF THE EARLIER MIDDLE AGES

A STUDY IN THE TRANSMISSION OF CULTURE

With a Revised Latin Text of Anatomia Cophonis and Translations of Four Texts

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BY

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Published by the Carnegie Institution of Washington
Washington, January 1927

CARNEGIE INSTITUTION OF WASHINGTON
PUBLICATION No. 364

NATIONAL PUBLISHING COMPANY
WASHINGTON, D. C.

FOREWORD

The anatomist, marching between the philosopher and the physician, has ever been their companion in the vanguard of man's struggle for truth and freedom through self-understanding. This is particularly true of the twelfth and thirteenth centuries, when Europe received again the Graeco-Roman learning preserved in Islam during Europe's Dark Ages. Mathematics and medicine, with its ancillary sciences, were the first to be taken over from the Orient and the first to be revised according to the scholastic method. In this movement the anatomists took a notable part in maintaining the continuity of thought and method. This much we know from the anatomical texts scattered throughout medical manuscripts of the earlier Middle Ages, sharing the attention of copyists and students with the clinical works of Galen and the Arabs; but we know all too little about the order and the dates of composition of the mediaeval anatomies, or of their sources and their authorship. Older studies in this field were based upon necessarily incomplete information, while recent contributions have mostly dealt with limited aspects of the problem. Meanwhile, the general study of mediaeval science has been advancing rapidly, and the medical historian finds many new sources open for investigation. For this reason I have attempted in the following pages to summarize recent research and to clear up, if possible, by my own studies, some of the obscure phases of anatomy in the earlier Middle Ages.

This study, begun some years ago, has been completed during a period of residence in England and France made possible by the University of Rochester. My gratitude is due especially to Dr. Charles Singer, Lecturer in the History of Science in University College, London, who provided constant encouragement and help and placed his library and his collection of notes and records freely at my disposal. Among others to whom I owe thanks are Mrs. Charles Singer; M. Wickersheimer, Librarian of the University of Strasbourg; M. Huet, genial custodian of the Municipal Library at Chartres; the officials of the Chartres Library and of all the other libraries mentioned in the text; Professor C. H. Haskins of Harvard for paleographic advice; and my wife, for frequent help and criticism.

GEORGE W. CORNER.

ROCHESTER, NEW YORK,
September 1926.

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INTRODUCTION

It was a very significant conjunction of events by which the passage of Arabic science into Latin began in the very decades when the Norman domination of all western Europe was completed. The first of our anatomical treatises dates from about 1070–1100, within a few years of the battle of Hastings and of Robert Guiscard's victories in the Campagna. The period of these books is also roughly coincident with the Crusades. Between the first and the last of them many of the older European universities were founded, and hospitals for the sick were established in large towns. The Norman walls of St. Bartholomew the Great in Smithfield, built in part while "Anatomia Cophonis" was being compiled, still overlook Bart's Hospital, whose earliest medical attendants perhaps learned anatomy from such manuscripts. At Chartres, similar manuscripts from the old cloister school (one of which we are to examine in detail) are still to be found preserved under the shadow of twelfth-century spires. At such a place the historian of anatomy or of any other ancient science feels no need to excuse his interest in the special writings of the time, when everything about him proclaims the unity and the continuity of mediaeval thought, and he sees in the books, in the towers, in the glowing windows of the cathedral the twelfth-century artist, philosopher, and physician, each in his own field, progressing from the simpler traditions of the East to the complex, overwrought, aspiring, and magnificent patterns of mediaevalism.

The Dark Ages; The Legend of Salernum

The history of the medical school at Salernum, through which European medicine was awakened after the Dark Ages, has been repeated over and over until it becomes difficult to separate the bare facts from the several kinds of conjecture which incrust them. There is a legendary Salernum, said to have been founded by four masters, a Greek, a Jew, a Saracen, and an Italian, where something of the pure Greek tradition had survived, in some unaccountable way, the turmoil of 800 years. In this "Civitas Hippocratica" we are told that there was a classical freedom of study and practice, a liberality so great as to permit the existence of women professors, an approach to the problems of disease, and a simplicity of therapeusis not unworthy of the Coan fathers. This legend has persisted with such vigor that medical historians, even in recent years, have been led to neglect as unimportant the Dark Ages and the dark regions among which Salernum alone is thought to have possessed the light of antiquity. Soberer modern history begins by admitting that we do not fully understand the reasons which made this town on the Gulf of Paestum, at some time before the twelfth century, the earliest center of

medicine in reviving Europe. Disregarding the legend, and going directly to the available records, it is now clear that the School of Salernum was not a miraculous relic of ancient Greece, but a new structure upon a foundation slowly laid down toward the end of the Dark Ages, with the aid of influences from across the Mediterranean.

The south of Italy after the fall of the Gothic power was a sort of outpost of Byzantium, in which the common speech was a corrupted Greek; but, as pointed out by Singer and Singer (1923) in their thoughtful essay toward a reconstruction of Salernitan origins, this tongue of the common people was not at first concerned in the reestablishment of science. There were three other more important cultural influences at work, however. First must be mentioned the monasteries, chiefly or entirely Benedictine, in which monkish Latin was spoken and read. Moreover, there were strong Jewish communities all over southern Italy, whose fortunes and misfortunes have been preserved in the chronicles of Jewish writers from the year 850 down. Finally, a series of Saracen raids and invasions of Sicily and the mainland, in the eighth and ninth centuries, led to the introduction of Saracenic colonies in southern Italy at a time long antedating the definite establishment of Salernum as a medical center. Perhaps (as Singer and Singer have suggested) it is these four linguistic elements which are symbolized by the Four Masters of Salernum. In their mingling by trade and warfare a basis was laid down for the later entrance of Oriental learning into Christian Europe; but in the period before the year 1050 all the evidence we have indicates that learning in general, and medicine in particular, was centered in the Benedictine monasteries. In these establishments, from the eighth to the fourteenth centuries, there was a large amount of writing done in Latin in a peculiar script, known as Beneventan, from the central Benedictine house at Benevento. About 600 manuscripts have survived to the present time, some of them still at the monasteries of Benevento, Monte Cassino, and Salernum. Among them are 14 medical works. This handful of works (studied by Singer and Singer, 1923), together with a few titles listed by Sudhoff (1922) from Chartres and elsewhere, a few Latin antidotaries and similar literature, a few in Anglo-Saxon and Welsh, and some Irish charms and magical texts, are all we have to inform us what sort of medical literature was current during the later Dark Ages. The more strictly medical books of the period consist entirely of translations, paraphrases, or extracts from older Greek works; the Latin transcriptions are often very corrupt and the copying often ignorant. The Greek works represented are certain pseudo-Hippocratic writings and books attributed to Dioscorides, Oribasius, Paulus of Aegina, Soranus, and other well-known medical writers of antiquity. The internal evidence indicates that the Latin texts had been put together as far back as the sixth century,

and that the monastic scribes had no Greek originals to guide them as they passed on the always more and more corrupt Latin versions.

Turning to the subject of our special interest, it may be said that, as far as the evidence goes, anatomy did not exist. No anatomical work of Hippocrates, Aristotle, Galen, or the lesser classical biologists is known to have been in use in Europe before the twelfth century. Singer's researches have disclosed nothing but one little confused anatomical text in Latin, among the relics in the Beneventan handwriting (as yet unpublished), and a few mystical accounts of man's body as a microcosm, composed for religious purposes, such as that of St. Hildegarde of Bingen. Nor has any anatomical text been traced to Chartres, to Ireland, or other of the known centers of learning in the Dark Ages. The vast anatomical learning of Galen had vanished from Europe and even from the land that knew his labors.

Salernum Before Constantine

This period of twilight in medical literature, and of continued darkness as far as anatomy is concerned, ends suddenly with the entrance of Constantine the African, about the year 1070. What there was at Salernum before Constantine arrived with his Arabic learning to begin the renaissance of European medicine, we hardly know. The famous Codex of Breslau contains a few small works (listed by Sudhoff, 1922) which seem to have a late Greek origin, and there are two books of medical import known to have been in use in Southern Italy about the years 1000–1050, though not definitely associated with Salernum itself. These are the "Practica Petroncelli" and a book on materia medica known as Diascorides Lombardicus, in distinction from the greater Diascorides whose name had been borrowed by its compiler. There is a third early work, the "Passionarius Galeni," whose author, one Gariopontus or Warimpot, is now in fact traced to early Salernum. Thus the men, whoever they were, who were practicing and teaching medicine at Salernum before 1070 had neither more nor less in the way of books than the men who had been writing in the Beneventan hand during the past two or three centuries, namely, a handful of corrupt compilations from long-lost Graeco-Roman originals.

Following Sudhoff, it has been customary to distinguish three periods of the Salernitan literature, namely, Early Salernitan, Middle or High Salernitan, and Late Salernitan. The "Middle period" begins with the work of Constantine. Before his time, as it seems to the present writer, there is no real proof that theoretical medicine was developed further at this town than elsewhere. Perhaps the place was frequented by patients, like a spa, or had some traditional reputation for healing. There is indeed a tale, quoted by Sudhoff (1922) from the "Historiae" of Richer of Rheims, which seems to show that Salernitan doctors, or one of them

at least, enjoyed a special reputation at the court of France as early as the year 900. Beyond this all is still legendary. The early Salernitan period was almost undoubtedly merely a continuation of the Lombard culture. We must abandon altogether the poetical view of this place as a last outpost of the true Hippocratic learning. Nothing remained here, any more than elsewhere in Europe, of undiluted antique medicine. The important thing that happened at Salernum, to set it off from the rest of Italy and to make its medical school preëminent in the grand awakening of Europe, was the introduction of Oriental learning at the end of the eleventh century.

Constantine the African

There is a legendary Constantine as well as a legendary Salernum. Our knowledge of the life of the great translator comes from two sources, on one hand a biographical account by his follower, Peter the Deacon (Librarian of Monte Cassino in the early twelfth century), and on the other hand a few contemporary notices and records, together with the internal evidence of the books which are associated with his name. Peter the Deacon tells us (the tale is pleasantly translated by Singer and Singer, 1923) that his master was born in Carthage and wandered throughout the Orient, in India, Babylon, Ethiopia, and Egypt. Spending nine and thirty years in study among these peoples and learning their languages, he returned to Carthage, but found himself too wise for the comfort of his townspeople, who feared him as a sorcerer and forced his departure. Arriving at Salernum in disguise, he was recognized and bidden to the court of Duke Robert Guiscard. In later life he became a monk at Monte Cassino, and here began to make use of his vast linguistic resources by translating a multitude of books into Latin suitable for the use of monastic scholars. In this task a pupil, Atto, took part by copying out "in elegant Latin" the texts which Constantine had drafted. There is also a vague legend that Constantine taught in person as a lay professor at Salernum before he became a Benedictine at Monte Cassino.

Disregarding the Deacon's tale and other stories, the bare and proven facts are very few. In the first place, we have a group of twelve or fifteen medical books, both in old manuscripts and in print, which have been associated for 800 years with the name of Constantinus Africanus. One of these books, the most important as it happens, for our present study, namely, the "Pantegni," opens with a paragraph in which "Constantine the African, monk of Monte Cassino" dedicates the book to Desiderius, abbot of that house, who became Pope under the title of Victor III for a half year in 1086–87. From the characteristics of the manuscripts and of those of other authors which contain excerpts from them, we know again that the Constantinian books were first written not earlier than about 1070. The man who prepared these trans-

lations knew Arabic and Latin and perhaps something of Greek. One or two men in the earlier decades of the twelfth century called themselves pupils of Constantine the African. This is all we know for certain; perhaps there is one more item of information in the recent discovery (Garufi, 1922; Capparoni, 1923) of a register of the confraternities of Salernum, in which the name Constantine is twice entered in the late eleventh century, once as Constantinus clericus and once as Constantinus subdiaconus. If this be Constantine the translator, he was already in orders before retiring from Salernum to Monte Cassino. Sudhoff (1922) points out that Constantine could have found in Sicily all the language and all the Arabic books needed for his work, and by putting together a few hints, suggests that Constantine had come up from Sicily with the army of Robert Guiscard, to whom the city of Salernum fell in 1077. This explanation of his career is at least more plausible than that of Peter the Deacon.

The books, although they mostly bear no other name than Constantine's, are all translations of various medical texts of Greek, Graeco-Roman, and Arabic origin, which were in active circulation in the Arabic tongue. We have at present a fairly clear knowledge of these books and their sources, thanks to the lifelong studies of Steinschneider (1866, 1905). The most important of them are the *Aphorisms* of Hippocrates, with Galen's commentary, from an Arabic version perhaps of Honein; *de Locis Affectis* (or *de Interioribus Membris*) from the Arabic version of Hobeisch; the *Microtechne and Megatechne,* with lesser Galenic and pseudo-Galenic works; the *Prognostics* and *de Regimine Acutorum* of Hippocrates; the *Dietetics,* the *Elements,* the *Fevers,* and the *Urines,* of Isaac the Jew; the *de Gradibus* of al-Djazzar; and the *Pantegni,* a translation of the *al-Maleki* of Ali Ibn al-Abbas (Haly Abbas).

The books translated from Isaac Judaeus were apparently ascribed from the first to their actual author, who was a Jewish physician in North Africa (d. 923); but all the others were put forward as Constantine's own, or at least without ascription of other authorship. As a result, almost the whole group of Constantinian translations were ascribed by some to Isaac Judaeus, while on the other hand the fact that they were all from Arabic original texts was from time to time forgotten, so that since their appearance there has been almost constant confusion and disagreement as to their source and authorship. Constantine has been accused of plagiarizing the *Pantegni* from Isaac the Jew (who must have died in fact before the original was compiled), and of various other plagiarisms; on the other hand, the post-Constantinian Salernitans seem to have considered him the actual author of the *Pantegni.* His Latin style has always been railed at as barbarous, though one might expect a little mercy to be shown a scholar who was for practical ends putting an immense technical literature into a language unused by science

for centuries past. Now that Steinschneider has traced the sources of Constantine's translations and made clear the relations between the writings of Constantine and Isaac, as described above, the moral issue as to plagiarism may well be dropped for want of evidence and of a fair standard for judging the actions of a past age. Equally futile would be a similar discussion in China of the year 3000 A. D., regarding the almost legendary persons who translated Gray's *Anatomy* and Osler's *Practice* into Chinese about the years 1915 to 1920.

At present the studies of Steinschneider, Sudhoff, and their pupils tend more and more to convince us that Constantine the African must be held among the founders of modern medicine and indeed of all modern biology. He gave the West, as Sudhoff puts it, a great mass of important classical learning, in readable Latin, at a time when everything was ripe for growth. For a hundred years all western medical science grew out of these books, and when the thirteenth century brought new translators who were able to comprehend and to translate Aristotle and Avicenna, their seed fell upon ground plowed by Constantine.

Manuscripts and Printed Editions of Constantine

Under the confusion already spoken of, some of the manuscripts (which are fairly numerous) bear ascriptions to Constantine and others to Isaac. Practically all the books were printed together at Lyons in 1515 as *"Opera Ysaac,"* and again but less completely at Basel in 1536–1539 in two volumes under the title *"Opera Constantini Africani."* It appears to have been common in Salernitan times to bind together Constantine's version of Galen's commentary on the *Aphorisms* of Hippocrates with the little ancient books of Philaretus and Theophilus, and various other small texts, for use as a hand-book; this collection survived until printing began and went through many editions under the name of "Articella" (i. e., "abridged practice of medicine"). Although this book, as printed for instance at Venice in 1523, ultimately contained post-Salernitan writings, such as a later version of the Aphorisms, it is essentially representative of Constantinian Salernum, and will serve as a source of information when we come to see where the Salernitan anatomists got their quotations from Hippocrates. The bibliographic history of the *Articella* is discussed by Töply (1898).

The Pantegni: Ali Abbas

The *Pantegni,* which in Constantine's version was to be so great an influence at Salernum, was composed in the later tenth century by Ali ibn al-Abbas, a Persian who is said to have been a court physician at Bagdad, dying in 994. The book is a complete system of medical theory and practice, attempting to summarize the whole of classical medicine as understood by the Moslems. Something of the sort had been attempted

a half century before, in the *Khitaab al-Mansuri* of Rhazes, and a greater was to be written a generation later by Avicenna. As we shall see, all three of these Arabic encyclopaedias were to furnish material for mediaeval anatomy, but the work of Ali Abbas was to be (through Constantine's translation) the first to reach Europe.

The word "Pantegni" is Constantine's apt Greek title signifying "the whole art," in allusion to Galen's *Mikrotechne* and *Megatechne*. The Arabic title of the book is *al-Maleki*, "the royal book," rendered later by Stephen of Antioch as *Regalis dispositio*. Its documentary history may be outlined briefly. Manuscripts in Arabic exist, but have not been collated by modern scholars. According to Sudhoff, the work was printed in Arabic in Egypt in 1877. In the Middle Ages it was twice translated into Latin, once by Constantine and again by Stephen of Antioch. The Constantinian version was printed in full in the 1515 *Opera Ysaac* and in part (the *Pars Theorica*) in the 1539 Basel *Opera Constantini*. Stephen's more refined translation appeared in print in 1492 at Venice and at Lyons in 1523. Pagel (1906) has transcribed the ninth book of the *Pars Practica* (on surgery) from a Berlin Latin manuscript, and de Koning (1903) has given us an invaluable French version of the anatomical portions of Ali Abbas, together with those of Rhazes and Avicenna.

The work is divided into two parts, the *Theorica* and the *Practica*, each of ten books. Some idea of the contents may be gained from the following headings of the books of the *Pars Practica*:

Book 1. Elements, complexions in general. Elements and complexions of parts of the body. Mutations of the complexions according to region, age, custom, humors.
2. Anatomy. The bones, cartilages, nerves, ligaments, veins, arteries, fat, membranes, skin, hair, nails.
3. Muscles, the brain, eyes, throat, and internal organs in order.
4. The "powers," i. e., sensation and motion.
5. Air and its mutations, foodstuffs, medicinal plants and substances, clothing, sleep, sexual activities.
6. Accidents, i. e., death and abnormalities, both anatomical and pathological.
7. The pulse; urine, and other excretions in health and disease.
8. On diseases of febrile and infectious type.
9. Local diseases.
10. Symptoms, crises, prognostics.

The two books on anatomy (Books II and III), as they appear in Constantine's version, form a systematic description of the tissues and organs of the body, dependent of course on the Galenic tradition, and without any evidence of actual observation of the animal body or of experiment. The book is couched in a tone of deep reverence, with frequent expressions of gratitude to the Creator. In this respect the Oriental writers found an acceptable example in their great master, Galen. Since space forbids the printing of specimens of the *Pantegni*

in English in this place, the reader who wishes to see for himself what it is like may be referred, in case the Latin editions are not accessible, to de Koning's French translation from the original Arabic.

At this point we may discuss a question brought up by various hints in the literature that Constantine was not an accurate translator of his Arabic originals. An authoritative solution of this question would of course require acquaintance with Arabic; lacking this, the writer has made shift to answer it, as far as the anatomical books are concerned, by comparing at some length the 1515 and 1539 editions of the *Pantegni* (which are identical) with de Koning's French translation of *al-Maleki* directly from the Arabic. The comparison indicates that Constantine's version contains all the original matter in a fairly literal translation. It must be admitted that the translator probably did not always comprehend the original, that he was often forced to take over an Arabic word for want of a Latin term, that he achieves a naïveté which exceeds the original; but on the whole he put the Salernitans in possession of a fairly comprehensible and complete rendering of the anatomical portions of Ali Abbas.

The Literature of Salernum; Our Materials for Its Study

After the advent of the Constantinian translations, the School of Salernum saw the appearance of a great amount of medical writing, among which we find as the subject of our present interest five treatises on anatomy. In order to set forth clearly the history of the anatomical books, it becomes necessary to discuss briefly at this point the general nature of the Salernitan writings and our present materials for their investigation.

Modern study of the field begins with the discovery by Henschel (*Janus,* 1, 1846), in 1837, at Breslau, of a quarto parchment manuscript of 225 leaves, written in a twelfth-century hand, containing 35 medical treatises. Recent reexamination of the book by Sudhoff (1920) indicates that it was actually written in Salernum about 1160–1170 as the private reference-book of a physician. Parts of the contents were published soon after its discovery by Henschel and his pupils, and other portions have since been transcribed and printed by De Renzi and by various students of Sudhoff (Hartmann, 1919, for bibliography), so that most of the Breslau Codex can now be found in print.

In 1852–1859, Salvatore De Renzi published his *Collectio Salernitana,* in five volumes, in which he gathered a great mass of Salernitan writings, in part from the Breslau manuscript, but also from various other sources in manuscript and in print. To these specimens of the Salernitan literature, De Renzi added extensive notes and chronologies dealing with the books and their known or supposed authors. Since De Renzi we have

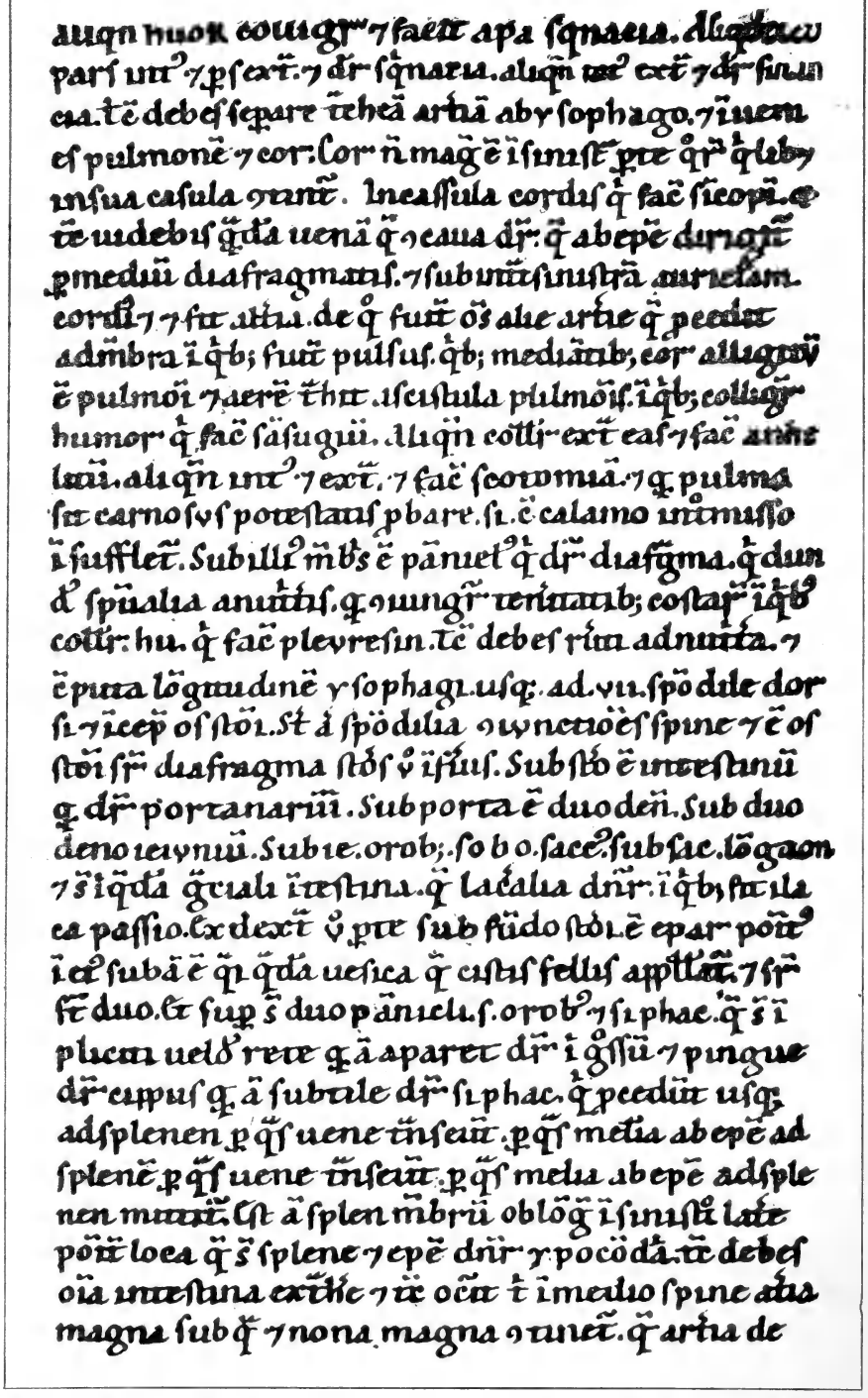
had further additions to the mass of Salernitan literature through the works of Giacosa (1901) and numerous others who have found manuscripts which could be proved or conjectured to be Salernitan. At the present time we know of more than 100 medical texts (including Constantine's translations) which are attributed to 30 or 40 authors. These books, which range in length from a few paragraphs to scores of chapters, deal with anatomy, pathology, semeiotics, therapy, surgery, gynecology, and ophthalmology.

Study of the Salernitan writings brings up at once a number of questions as to where and when each was written, the nature of its sources, the name of its author; but the books themselves do not always yield the desired information. Copied by hand from decade to decade, often by scribes who did not have the faintest understanding of their contents (see below, page 20), the texts became corrupt. The names of the original authors or compilers, if recorded at all, were lost by error, by omission, or by substitution of another name. There was a tendency to ascribe any or every medical book to Galen or some other great writer. Many a mediaeval medical text bears at its head *Liber Galieni,* when in the contents another author is plainly named. The three known manuscripts of the *Anatomia Vivorum,* for instance, are headed respectively by the names of Galen, of Aristotle, and of Ricardus Anglicus. When after 1490 some of the Salernitan texts were printed, the confusion of authorship was even more firmly perpetuated.

Unfortunately, the precautions against error, which are suggested by what has been said, have not always been observed by writers on the history of Salernum. De Renzi himself, to whose energy and erudition we owe so much, often accepted without question the baseless assertions of authorship found in the manuscripts, and even allowed himself to found new conjectures upon them. His collection contains, on the other hand, some material that is probably not Salernitan. As a result, the names and dates of the Salernitan doctors, as they are passed along in modern writing of the uncritical school, are quite untrustworthy, and the history of Salernum is surrounded with all sorts of fictions, of which the legend of the two Cophos is an example. The subject is badly in need of an authoritative critical analysis, for which new information yearly accumulates, chiefly through the admirable work of Sudhoff and his pupils. There is a recent summary of the literature by Hartmann (1919), to which the present writer gives assent all the more readily from having arrived by independent research at similar conclusions regarding a small part of the field so largely covered by the Leipzig school. By cautious analysis of all available manuscript material, and by the use of such newly discovered documents as the *Liber Confratrum* and the *Obituary* of Salernum Cathedral (Garufi, 1922; Capparoni,

1923) we may hope to clear away the fables and learn the solid truth about Salernum. Meanwhile, we may properly demand of all who venture to write about medicine in the twelfth and thirteenth centuries, that by toiling over the original sources and by familiarity with the manuscripts they learn the difficulties and the pitfalls of their subject. In such a spirit of humility I turn to the special problem of our inquiry.

FIG. 1.—Portrait of Constantinus Africanus, from initial letter in MS. Bodley 489, fol. 2, verso (a manuscript of the *Viaticum*, written in the second half of the twelfth century, probably of Italian origin). ×1.4. From Dr. Charles Singer, by courtesy of the Bodleian Library, Oxford.



A page of the earliest known manuscript of the *Anatomia Cophonis,* Munich. Hofbibliothek, Codex Monachensis lat. 4622, fol. 38, recto. Actual size.

TWELFTH-CENTURY TEXTS

DEMONSTRATIONS OF ANATOMY

First Salernitan Anatomical Demonstration (Anatomia Cophonis, Anatomia Parva Galeni)

The text which goes by the name of the *Anatomy of Copho* was first printed in the early sixteenth century from manuscripts which can not now be identified. The first known printed edition (called to the writer's attention by Dr. Charles Singer) is included in a small book containing a number of medical works by various authors and bearing the title *Divi Mesue Vita,* printed at Lyons in 1531. In this book the *Anatomia* is appended without separate title or even a break in the page, to the end of the work *De modo medendi,* which is ascribed here, as usual later, to Copho. It was again printed in exactly the same way several times before 1550 in various editions of Mesue (Erchenbrecher, 1919). Haller, in his *Bibliotheca Anatomica* (1774–1777) refers to a Venetian edition of 1502, which I have not been able to find. In 1537 the text was included in the *Anatomia* of Dryander, who now for the first time placed the name of Copho at its head, with a preface in which Copho is called the "most famous anatomist of his century." The last printing of this text as a useful document is found in the *Zootomia Democritea* (1645), Severino's compendium of comparative anatomy. Meanwhile, an almost identical version (with two more sections, on the brain and the uterus) had crept into the earliest complete editions of Galen; it acquired the title of *Anatomia parva Galeni,* and took its place among the Galenic apocrypha in the Venice Galen of 1541, the Basel (Froeben) of 1542, the Giunta of 1576, and others.

When De Renzi was making his great collection he was unable to find any manuscript of this text, and was forced to copy it from Severino. Recently, however, several have been discovered, in forms more or less allied to the printed version. Most curious among these is a manuscript of the thirteenth century, found by Schwarz (1907) in the Würzburg library, which begins with the familiar words "Quoniam interiorum membrorum corporis humani positiones," but which gives a much longer and more rambling text. Schwarz believed that he had found the actual original work of Copho, of which the text previously known under Copho's name was a corrupted relic; but this was disproved by Redeker (1917), who was able to analyze Schwarz's text into two elements, one the familiar Copho text and the other an unknown hypothetical text of somewhat later composition. Both of these Redeker actually found when he made a search for his hypothetical text, side by side in a twelfth-century manuscript in Munich (*Codex Monacensis,* Lat. 4622). It

appears certain that from this or a similar manuscript the aberrant version discovered by Schwarz was compiled.

The original Copho text of the Munich manuscript, thus brought to light, is the earliest so far found; it is written in a fine, clear hand. Dr. Singer, who has kindly examined photographs sent me from the Munich library, informs me that from the paleographic character of the writing he puts its date at about the year 1150; it might possibly be somewhat earlier, but can not be as late as 1170. The hand is of a northern type, possibly German. The text of this manuscript is practically identical with most of the printed versions. It seems, however, to have been written out by a copyist who was so unfamiliar with the vocabulary that he substituted in several places meaningless or inappropriate words for those of the original, i. e., *scistula* for fistula, *scotomiam* for orthomiam, *carnosus* for cavernosus (referring to the lung), *mecides* for uritides, and also in one place *nona* for vena. On the other hand, this manuscript affords in a few passages a more intelligible reading than the other versions.

The two sections on the brain and the uterus which conclude the text as it appears in the editions of Galen have been something of a mystery. In the first place, they are absent from the version handed down in the name of Copho; in the second place, we have had no manuscript authority for them; in the third place, they contain a passage which the sixteenth-century editors of Galen had to print in nonsensical Latin (i. e., "scinditur more gravis"), because they were unable to decipher the abbreviation in whatever manuscript they had. A search in the Bibliothèque Nationale at Paris disclosed to me two fourteenth-century manuscripts, one of which (Lat. 7030A) contains the passage on the uterus and the other (Lat. 7036) contains on folios 105–106 a complete Copho text with the sections on uterus and brain, almost exactly like the version in the Giunta Galen. Moreover, the former manuscript gives an obviously correct reading of the phrase which baffled the old editors (see page 50, note 1).

Since there is no printed edition of this text which is free from obscurities or corruptions, a reconstructed text, made by free use of all the printed versions, together with the Munich and the Paris manuscripts, is presented (page 48). The result, which is offered for what it is worth, at least provides for the first time in 750 years a text which is completely intelligible and probably represents the sense of the original more closely than any extant version. The reconstructed text has also been made the basis of our English translation.

The association of this anatomical demonstration with the name of Copho is entirely groundless. We have seen that it began as late as 1531 through the printing of the *Anatomia* immediately after a medical text alleged to belong to Copho. Dryander, Severino, Haller, and De Renzi accepted the error without inquiry, so that it has been handed down by

all subsequent writers until Sudhoff questioned it. In the manuscripts the book is always called *Tractatus anonymus de anatomia* or *Anatomia Galieni.*

About Copho himself we have only one piece of contemporary evidence. In the introduction to an undoubtedly Salernitan book, *De modo medendi,* the compiler says: "Ego namque secundum hoc opus de modo medendi a Cofonis ore suisque et sociorum scriptis compendiose collegi." This seems to have been enough to lead the editors of the earliest printed versions, and even De Renzi, to consider Copho the author of *De modo medendi.* Furthermore, since the book refers to certain drugs as "of Copho," De Renzi assumes that there must have been two Cophos, and so we have a full-fledged legend about a medical family of the Cophos, with dates (De Renzi, vol. 5). On the other hand, Erchenbrecher (1919) has turned up a manuscript of *De modo medendi,* in which one Archimatthaeus names himself as the author who compiled the book "from the sayings and writings of Copho and his colleagues." The name of Copho does not appear at all in the list of Salernitan confraternities nor in the Cathedral obituary (Garufi, 1922; Capparoni, 1923). Thus Copho is reduced to the shadowy figure of a man, who was, no doubt, a teacher at Salernum, but the author of no known writings, and without known date.

Our study of the contents and the probable date of the text itself will best be postponed a few pages until we have discussed the next text.

Second Salernitan Demonstration

The Second Salernitan Demonstration, unlike the *Anatomia Cophonis,* became known as a historical document directly from an early manuscript version; discovered by Henschel in the Breslau Codex in 1846, it was first transcribed by his pupil, Nagel, in 1852, and again in 1853 in De Renzi's *Collectio Salernitana.* These transcriptions are unfortunately not very accurate, and the text is marred by a number of unintelligible passages. In recent years, however, Sudhoff has discovered a second manuscript of the work in the Erfurt *Amploniana* (Codex 204, fol. 82–85) dating from the late twelfth or early thirteenth century, and his pupil Benedict has printed a revised text (1920) based on both the manuscripts, incidentally correcting the errors of the earlier editors. Benedict's text has served as the source of our translation, which, like that of the First Demonstration, is the first English version to be printed.

Analysis of the Second Salernitan Demonstration; Sources of Its Contents

An examination of the Second Salernitan Demonstration shows that it is arranged as a public discourse or lecture to accompany a dissection of a pig. The work opens with a formal introduction in the scholastic style, in which the various organs are classified in a somewhat rigidly

schematic way according to their respective functions in mediating the three species of vital spirits. This prologue duly recited, the lecturer gives directions for killing the pig and arranging the carcass, and proceeds to conduct a systematic examination of the various organs, giving as he comes to each region a few words of guidance to the dissector, then a description of the region or organ, and finally mentions one or more diseases or lesions which may affect the part under examination. During the course of the lecture the speaker several times refers to certain books in which he hints that his remarks will be found corroborated or extended. These are the *Pantegni* of Constantine, the *Liber Urinarius* of Isaac the Jew, the *Aphorisms* of Hippocrates, and an unnamed work of Galen, which, as we shall see, was in fact Galen's *Commentary on the Aphorisms,* another of Constantine's translations. There are also three passages in which the anatomical lecturer refers respectively to Philaretus, author of a well-known work of post-classical origin, *De pulsibus;* to Johannitius,[1] no doubt the author of the celebrated *Isagoge* (Honein), and to the *Aphorisms* of Hippocrates, using in each case terms which indicate that he is quoting from commentaries of his own authorship upon these works (e. g., "ut in Philareto diximus"; "in glosulis aphorismorum plenarie diximus"; "prout in Johannitium diximus").

A detailed examination of the text reveals the fact that the Salernitan anatomist has drawn the prologue and all the formally descriptive parts of his discourse from the *Pantegni.* Some of his paragraphs are taken almost bodily from the original, some are greatly condensed, others represent a reworking of the original text, in which, however, the vocabulary and even whole phrases and sentences are those of Constantine. The following specimen passages in parallel will show one bit of description which is copied almost literally and another which has been considerably reworked; these illustrate better than any further discussion how completely the Demonstration follows its source in these descriptive passages and in the prologue.

[1] As incorrectly transcribed by De Renzi, the reference is to "Johannes," which led Töply to assume that Johannes Damascenus was meant.

CONSTANTINE

PANTEGNI, LIB. II, CAP. I

Natura enim mirabilis de multis membris in quantitate et qualitate diversis corpus animalis composuit. Ut per ea regeretur animalium quodlibet quod in suo vigore eviveret, ut expleret ad quod factum est naturaliter. Unumquodque enim animal corporis instrumenta animae, virtuti habet competentia. Quia leo cum sit animae audacis et iracundae, corpus forte habuit et grave. In pedibus ungues et in ore acutissimos dentes. Lepus cum sit timidissimus, corporis membra levitate nimia fugae habuit aptissima. Quia virtutes animae sibi erant diversae, fecit Deus corporis instrumenta virtutibus suis diversis competentia, ut pote manus in homine ut in eis operaretur, in quibus sunt digiti multi et diversi, ut per eos magna et minima possent retineri. Epar rubeum fecit prout suppetebat creando sanguini. Mammillas et testiculos ad creandum lac et sperma fecit albos. Hoc modo omnibus suis actionibus fecit convenientia.

DEMONSTRATIO ANATOMICA

Natura etenim prima et provida et in suis operibus mirabiliter collaudanda ex multis membris vel quantitate et qualitate diversis corpus composuit animale, ut per ea animalium constaret regimen et suae vigor existeret et ad quae facta sunt consisteret explementum. Nam unumquodque animal corporis membra animae et naturae habet instrumenta competentia. Leo namque, cum sit animae audacis et iracundae, ad utriusque perfectionem corpus habuit forte, et instrumenta habilissima extiterant in pedibus scilicet ungues et in ore acutissimae dentes. Lepus vero, cum sit animal timidissimum, corporis membra levitate nimia fugae, habuit aptissima crura scilicet anteriora posterioribus curtiora ut ita ascensus fieret facilior. Quia quorum virtutes et naturae animae sibi erant diversae, summus opifex et pater universorum virtutibus diversis instrumenta composuit singulis competentia utpote manus in homine, ut cum his operaretur. In quibus multi sunt digiti et diversi, ut per eos magna et parva possent retineri. Epar rubore affecit ad maioram sanguinis generationem. Mammilis et testiculis ad lactis et spermatis creationem provida discretione praestitit albedinem. Sic itaque membra universa cunctis actionibus suis fecit convenientia.

LIB. III, CAP. XXI

Cor fit de villis diverse positis, cuius caro tota est dura. Diversitas villorum ex diversitate est motuum, dilatandi scilicet et constringendi durities carnis, ut velocitas auferatur passibilitatis. Pulmo circumdat cor lateraliter. Forma cordis est pinea. Inferius

Post haec inspicetis cor in eodem latere sinistro locatum, a pulmone lateraliter circumdatum, et quodam panniculo undique opertum, qui dicitur casula cordis, in qua bene potest apostema fieri, in corde vero numquam aut difficile. Saepe autem in eo super-

eius pars id est, latitudo, opposita est superiori corpori. Ponitur autem intra concavitates pectoris ambas quas mediante panniculo diximus esse diversa. Caput quod acumen dicitur in sinistro parte locatur. Hoc vero latus cordis spiritus inhabitat vitalis. Inde exit arteria maior, de qua omnes aliae egrediuntur. Unde fit ut pulsus in sinistra parte sit fortissimus. Cor duas habet concavitates, quorum una dextra, altera vero sinistra . . . (28 more lines follow, in which the internal structure of the heart is described in detail).

habundat corruptus humor, qui facit sincopim ut in substantia cordis de villis scilicet de partibus villosis et nervosis diverse positis, et carne dura est composita; et hoc est propter motuum dilationes scilicet et constrictionis diversitatem eorundemque magnitudinem et velocitatem, ne molli substantia compositum ex his facile compateretur. Sed forma eius pineata est inferius lata superius acuta, concava ex diversis concavitatibus, ut et facilius fieret motus et ne in angulis retenta superfluitas causa esset molestiae.

Lib. III, Cap. XXXVI

Virga caro est nervosa, rotunda et concava, ab utroque penis osse incipiens et utrumque nervos sibi oppositos extransverso habens. Quae duplici ex causa fuit necessaria. Primo, ut per vasa sua sperma in vulva proiciat. Unde etiam fuit nervosa, ut appetitum concupiscientiae in tactu habeat. Concava efficit, ut accedente appetitu vento impleatur, unde erigatur. Ambo lacerti lateraliter sibi sunt oppositi, ut nusquam virga possit flecti. Unde rectum sperma in vulva proiciat. Secundo, quia cum vesica viae spermatis et sit vicina ac eadem via emittit urina . . .

Virga est quasi caro nervosa et rotunda et concava incipiens ab utroque osse pectinis duobus nervis ex transverso sibi oppositis constans, quae duplici de causa fuit necessaria. Primo, ut per vasa sua in vulvam prohiciat sperma, unde fuit nervosa, ut in spermatis emissione et tali actione turpissima pro nimia sensibilitate magna fieret delectatio. Concava fuit, ut huius actionis exardescente desiderio multo spiritu in magna concavitate et lacertis lateraliter positis sibi contento in summam extenderetur et erigetur rigiditatem et non facile posset flecti, sed recto transitu sperma prohiceretur in vulvam. Secundo fuit necessaria, ut urinam de colo vesicae sibi continuo sine offendiculo in virgam transeuntem recipiens expelleret. Ut in anatomia patenter ostendimus, penna per collum vesica immissa.

A parallel between certain other chapters, such, for instance, as the highly interesting descriptions of the uterus and the formation of the foetus, which can not be given for want of space, would show a degree of selection and reworking somewhat more extensive than in the paragraph on the heart, but even here it is possible to find somewhere in the long descriptions of Constantine practically all the ideas and a large proportion of the actual phrases used by the Salernitan demonstrator.

The foregoing parallel has been noticed, though briefly, by Töply (1898) and Redeker (1917); it accounts for a great part of our text. Nor have we much farther to look for the sources of the brief pathological notes which occur throughout the Demonstration. A clue is given by the quotation from Hippocrates (page 63): "unde in Aphorismis 'quibuscumque ex strangiria' et alibi 'in ano flegmonem patientem,' et cetera." This is an exact quotation from Constantine's translation of the *Aphorisms* with Galen's commentary (Aph. VI, 4, and V, 56); following it up, we find other quotations from the appended comments of Galen. Thus the passage about abscesses between the oesophagus and spine (page 58) closely follows Galen's comment on Aphorism III, 27. Other passages, though not actually quotations, are very reminiscent of Constantine's translation of the *Aphorisms,* for instance, the classification of abscesses of the throat (Galen on Aph. IV, 34) and the causation of sneezing (page 57), which suggests Galen on Aphorism VII, 51. I can not trace one of the quotations from Galen ("per species disniae et tussis quaeque fiunt"), but excepting this it is quite safe to say that all the lesions mentioned in the pathological notes, and the phraseology employed in connection with them, can be traced to this one source.

The two references to Isaac's *Liber Urinarum* are both to be found in the printed text of that book; it is interesting to note that the sentence referring to the term *porta* (pylorus) is an exact verbal quotation from Isaac.

The author of this work remains unknown by name, but he has left us a few clues by which we may hope that his name and place in Salernitan history may some day be recovered. We have noted that in this anatomical text he hints that he has written three other books, namely, commentaries on Johannitius, on Philaretus, and on the *Aphorisms* of Hippocrates. He tells us (see page 59) that in this latter work he has given a full description of the veins of the upper part of the body, when expounding the Aphorism "Posteriora capitis dolentia, in fronte recta vena incisa iuvat." There is obviously a clue here, to be traced by searching for an early twelfth-century commentary on the *Aphorisms,* based on Constantine's translation of the Hippocratic text and containing an anatomical exposition of Aphorism V, 67.

This is not the place for a disquisition on the early mediaeval glosses on the *Aphorisms,* but it may be said at least that there are numerous such commentaries in manuscript, which have never been classified or studied. Among them may yet be found the one which is claimed by our second Salernitan anatomist. One only of these glosses has been printed, namely, one bearing the name of Magister Maurus of Salernum, found by Daremberg in a manuscript of Vienna University and printed by De Renzi in the *Collectio Salernitana.* A certain polemical and independent tone displayed in this commentary, together with its undoubted Salernitan style, led Sudhoff to make the interesting suggestion that in this same Maurus we have the author of the Second Salernitan Demon-

stration. Unfortunately, there was no possibility of testing this hypothesis by reference to the gloss on the aphorism "Posteriora capitis dolentia, etc.," because a large fragment of the text is missing, including the fifth book. I have myself had the good fortune to discover two complete manuscript texts of the same book in the Bibliothèque Nationale, Paris (MSS. Lat. 18499, 6956) of the thirteenth and fourteenth centuries, respectively, both of which contain the missing parts. One of them is attributed to Magister Maurus, the other to Petrus Hispanus. The gloss on Aphorism V, 67 (MS. Lat. 18499, fol. 106, recto et verso) reads as follows:

Posteriora capitis dolentia, etc. Ponit auctor in hoc loco quandam curam doloris posterioris partis capitis per antipase. Aliquando enim dolor est infixius in posteriori parte capitis perveniens ex sanguine, tunc igitur minutio facienda enim de vena existente in media fronte (ut) ratione minutionis humor perhabundens in posteriora parte . . . . vena trahitur ad partem anteriorem et sic deficiente materia in parte posteriori qua dolor facit et dolor desinit nec tamen attractus humor ad partem anteriorem causa est doloris propter manitionem factam per minutionem. Hoc est igitur quare dicitur vena incisa fronte si posteriora partis dolentia iuvat.

It will be seen that this passage does not meet the description which our Salernitan anatomist gives of his own gloss on Aphorism V, 67, and that Sudhoff's hypothesis is thus rendered improbable.

I have examined several other early commentaries on the *Aphorisms*, especially such as are found in company with glosses on the other texts on which the Second Salernitan demonstrator claims to have made comment, namely, upon Johannitius and Philaretus; but I have found no one of them which quite fills the specifications of our search. At Chartres there is a twelfth-century codex (No. 171) containing, among other works, anonymous glosses upon Johannitius, Philaretus, and the *Aphorisms;* in the first two there are anatomical disquisitions on the eye and the venous system which might very well be those to which our author refers; but here again the gloss on "Posteriora capitis dolentia" contains no anatomical discussion. Another such collection, in which the various commentaries are found in company with the *Signa Prognostica* attributed to Ricardus Anglicus, exists at Würzburg (M. p. med. q. 1, Schwarz, 1907), but once more the gloss on "posteriora, etc." (kindly transcribed for me by Professor Sticker) is not apropos.

MS. Lat. 7027 of the Bibliothèque Nationale (Paris) contains a very interesting early Latin gloss on the *Aphorisms* which does give a kind of anatomical discussion of "Posteriora capitis dolentia," but the work is based on a translation of the *Aphorisms* which differs from that of Constantine, while its archaic style, as well as the paleographic characters of the manuscript, suggest that the work dates from pre-Constantinian times.

In summary, then, the Second Salernitan Demonstration is largely formed from material existing in three books of the collection translated by Constantine. There is nothing in it which need be considered earlier than these books, while on the other hand, if put together later than the twelfth century, we should expect it to show the influence of other anatomical works which came over from the Arabic by that time, such as Stephen of Antioch's translation of Ali Abbas. Sudhoff's dating of the Breslau Codex also gives us a terminus ad quem for the composition of this Demonstration, namely, the years 1160 to 1170. The evidence strongly points to a date of composition not far from the year 1100.

Probable Date and Source of the First Salernitan Demonstration

The *Anatomia Cophonis* contains no references to other books, nor any obviously recognizable quotations from preceding texts, and therefore its derivation is not so easily traced as that of the Second Salernitan Demonstration, and indeed must remain, for want of positive internal evidence, more or less a matter of conjecture. Töply (1898), like De Renzi, accepted the ascription of its authorship to Copho of Salernum, and thus assumed a date between 1085 and 1100, the years during which Copho is said by De Renzi to have flourished. Töply, however, supports his estimate of the general period of the work by listing its anatomical vocabulary, which, as he says, shows dependence upon both Greek and Arabic sources, and especially upon the *Liber Pantegni* of Constantine.

Yet, as we have already said, the text is so much briefer and less detailed than the other anatomical books which we now know to have been abstracted from the *Pantegni,* and it bears, at least superficially, such an archaic appearance that it is not difficult to imagine for it an origin in pre-Constantinian times. Two of Sudhoff's pupils, who are the latest to touch upon the subject, are in opposition on this point, Redeker (1917) speaking for a common dependence of the two Salernitan demonstrations upon the *Pantegni,* Benedict (1920) ascribing to the *Anatomia Cophonis* a descent from the times of monastic medicine, or at least from pre-Constantinian Salernum. Benedict means no doubt to suggest that we have in this work a traditional work of the Dark Ages, which was later revised under the Arabist influence and so acquired a partially Arabic vocabulary and style. Sudhoff himself (1922) calls it pre-Constantinian.

The terminology of *Anatomia Cophonis,* when analyzed, is not definitely enlightening as to its time of origin. Here we rest largely upon the scholarship of Hyrtl (1880) and Fonahn (1922). A few of the anatomical terms appear to come directly from pre-Constantinian times. *Longaon* is in Isidor of Seville's book of etymologies (seventh century) and is found also in the ninth-century text of the Glasgow Hunterian Library, to which reference has already been made (page 11). Con-

stantine uses *intestinum rectum* in place of this term. The older word *oesophagus* is used in the *Anatomia Cophonis* as against the Arabic word *meri* in Constantine. Copho uses both *omentum,* a classical Latin word, and the Arabic *zirbus,* without any clear evidence that the writer was aware of their equivalence. On the other hand, the text contains words of Latin form which are undoubtedly translations of Arabic terms, or which have some other late-Latin origin, such as *portanarium* and (in the terminal section on the brain, from the Galenic collections), *pia mater* and *dura mater. Stomachus* is used, not to signify oesophagus, as in the classical Greek sense, but in the Constantinian sense of "stomach." Finally, there are the three obvious Arabic words, *siphac* (peritoneum), *zirbus* (omentum), and *vena chilis.* It will be seen from this list of terms that the text as it stands can not be earlier than the period of the Arabic translations. It is either a pre-Constantinian work revised under the new influence, or else it is post-Constantinian, but prepared by a writer who was not fully a master of the new vocabulary.

It is when we pass from a consideration of the vocabulary to that of the contents that we are struck by certain points of relationship to the Second Salernitan Demonstration. The two works not only approach their common task, that of conducting a public dissection of the pig, in a generally similar way, but they are arranged in the same order, dealing first with the neck, then with the chest and abdomen, then with uterus and brain. They become vague and sketchy on similar subjects, as, for instance, the blood-vessels and the abdominal membranes. They agree in totally omitting the skeleton, except the cranium. They intermingle in the same way anatomical, physiological, and pathological discussion. They mention in general the same lesions and symptoms.

Most curious of all, the author of the Second Demonstration takes occasion five times to deny or correct certain statements of other anatomists; and four of these statements are actually made in the *Anatomia Cophonis.* The writer of Copho speaks inaccurately of glands called pharynges; the other anatomist remarks "quos quidam appellant faringes, quibus non do assensum." The former again says: "sub stomachum est intestinum quod dicitur portanarium"; the latter says: "quorum primum non est portanarium, sed duodenum." They disagree again about the omentum.

All these antitheses were pointed out by De Renzi, but another which is more interesting still has never been noticed, having been obscured by an unintelligible misreading in De Renzi's text. The author of the *Anatomia Cophonis* adds to his list of the divisions of the intestines a gratuitously false description of "certain intestines called lateralia, in which occurs iliac pain," a description which, so far as I know, is not found in any other anatomical text, and which must represent a sheer lapse of the author's understanding. In the Second Demonstration,

speaking of the colon, we find "the iliac pain caused by the retention of coarse refuse, and by other causes mentioned in the books, is, according to Constantine, located here, and not in 'lateral intestines,' which I have never discovered in animals, nor have I found anything written about them except in the recent booklet (in novo quaternulo)." Can the *Anatomia Cophonis* be the "recent booklet" thus attacked? The evidence falls short of proof, yet it is impossible to read the two texts together without surmising with De Renzi that the two Salernitan Demonstrations are contemporaneous, and that the second is in part a specific criticism of the first. Each is an adaptation of the newly acquired Arabic learning to the practical purposes of a public anatomical demonstration. One may conjecture for himself under what circumstances of emulation or rivalry they were prepared. It appears that the more inaccurate and less compendious author won the larger reputation, judging from the relative number of manuscripts and printed texts which have seen the light.

Anatomia Mauri

The *Anatomia Mauri* is a third brief text (173 lines of octavo print) found by Sudhoff in a twelfth-century manuscript in the Vatican Library (Pal. lat. 1097, fol. 122) and edited by Ploss in 1921. The work ends with the words "explicit liber anathomiae. Hoc opus a Mauro restat, pretiosius auro." The Maurus thus mentioned is no doubt Magister Maurus, a teacher known to us through references of Aegidius Corbolensis, whose teacher he was at Salernum in the latter half of the twelfth century. Capparoni has discovered in the Salernitan necrology an obituary notice of "Magister Maurus, optimus physicus," who died on the 24th day of February, 1214, and of his wife Theodora at the middle of February 1239. The other works attributed to Maurus are the *Regulae Urinarum* (Collect. Salern., III, 2–50, and also Kadner, 1919); *De Flebotomia* (R. Buerschaper, 1919); and the commentary on Hippocrates's *Aphorisms* which is discussed at length on pages 25, 26.

The text is a brief discourse intended to accompany the dissection of a pig, in the same style as the *Anatomia Cophonis* and the *Demonstratio Salernitana.* Like these texts, it begins with a definition of anatomy, with reasons for choosing the pig as object of study and with directions for killing and bleeding the beast. The description of the organs is given in the same order; a few pathological notes are included, very similar to those of the other two Demonstrations; and finally, the text concludes with a description of the brain, cerebral membranes, and eyes.

Although this text resembles that of the *Anatomia Cophonis* as against that of the Second Demonstration, in that it does not contain whole sentences and passages taken bodily from Constantine, still there is no doubt that the work has a purely Constantinian origin. The technical vocabulary is that of the *Pantegni,* without evidence of later scholastic

influence, nor is there any anatomical information in the work which can not be found in the same form in the *Pantegni.*

The *Anatomia Mauri* contains three quotations, one from Isaac and two from Hippocrates. The first occurs in connection with a passage mentioning six nerves or muscles on the under side of the tongue, whence "dicit Ysaak ad lingam sex lacerti veniant, quibus carent ceteri sensus." The second quotes Hippocrates to the effect that disease of the throat is due to over-desiccation or to repletion of that region. These quotations I have not been able to trace to their source in the authors mentioned; but the third quotation gives striking testimony to the exact version of Hippocrates which served as the author's reference-book. Speaking of tongue-tie, the author says: "unde Ypocras in aforismos 'trauli a dyarrhia maxime capiuntur longa.'" On turning to the *Articella,* we find that the words quoted from Hippocrates are the exact words of the thirty-third aphorism of Book VI, in the "antiqua translatio," i. e., Constantine's translation of the *Aphorisms.* In the second and later version of the *Aphorisms* given in the *Articella,* the wording of this aphorism is quite different.

Summary

The three Demonstrations, as we have seen, were composed during the twelfth century, probably before 1150, as the practical manuals of teachers and students whose only written anatomical authority was the *Pantegni* of Constantine. In one respect, however, they were not dependent upon their source; that is to say, in practical sense, in polemic vigor, and ardor for truth. If we do not find the Salernitan anatomists improving upon the science of their predecessors, we may at least respect them as careful and exacting schoolmasters. The three little books taken together give us a lively picture indeed of these men engaged in actual dissection of the animal body, surrounded by questioning pupils for whose benefit they try to fit their newly recovered relics of Galenic description to the pig's organs before them; now dogmatic, now puzzled; careful in demonstration, resentful of criticism; in short, living men, teaching from the specimen and not from books alone—an unexpected thing in mediaeval anatomy, not to be seen again until the days of Mundinus.

SYSTEMATIC DESCRIPTIVE ANATOMIES

Anatomia Ricardi (Salernitani) and Anatomia Magistri Nicolai

European libraries contain many examples, in handwriting of the thirteenth, fourteenth, and fifteenth centuries, of a text beginning with a very obvious remark in some such words as these: "Galieno testante in Tegni quiscumque interiorum membrorum corporis humani dispositionem scire desiderat, ipsum in anatomia exercitatum esse oportet." One such text was first noticed by Daremberg and Haeser and was

printed as the *Anatomia Ricardi* by Florian from Haeser's transcription in 1875 and again from the same manuscript in 1898, by Tarrasch. Both these transcriptions contained numerous inaccuracies. In 1907 Schwarz printed a correct text of *Anatomia Ricardi* from a Würzburg manuscript which he had collated with the Berlin manuscript and with several others. Finally, Redeker (1917) has brought forward, from a manuscript in the British Museum, a text differing from the foregoing but closely related to it, under the name of *Magister Nicolaus.* This is the text we present in English translation. Redeker's admirable dissertation goes so fully into the whole history of these Ricardus texts that in our present discussion we can do little but acknowledge the correctness of his results from personal study of most of the same material.

The most important of the manuscripts so far known (many others exist) are as follows, in approximate order of age:

Oxford. Bodleian, Codex 8847 (thirteenth century, first half). Anatomia. "Galienus in tegni testatur. . . . Unde tantum masculos vel feminas generant. Explicit anatomia." (Redeker, 1917.)

Würzburg. K. Universitäts-Bibliothek. "Hic incipit Anatomia Galieni. (m. p. med. q. 1. saec. XIII). Galienus testatur in tegni . . . vel tantum masculos vel tantum feminas generant. (Schwarz, 1907.)

Erfurt. Amploniana, fol. 288 u. 4° (thirteenth century). Anatomia Ricardi. (Schwarz, 1907.)

Erfurt. Amploniana, q. 15 (nr. 2a) fragment. Anatomiae cuiusdam Alani haud rectae attributae, potius Galieno attribuenda pars. (Schwarz, 1907.)

Paris. Bibliothèque Nationale. Anc. Fonds. lat. 7056 (thirteenth century). "Incipiuntur opera magistri Ric. Ricardi Anglici incipit anatomia. Galieno testante in tegno quiscumque interiorum membrorum . . . omnium membrorum habent commune. Sic nil omissum de membris praeterit hec artis. Explicit Anatomia M. Ri."

Vienna. Hofbibliothek, nr. 2325, dated 1280 A.D. (Schwarz, 1907.)

Vienna. Hofbibliothek, nr. 4153, dated 1314 A.D. (Schwarz, 1907).

Berlin. Kaiserliche Bibliothek, fol. 219 (fourteenth century). Anatomia Richardi. "Galienus in tegno atttestatur . . . vel masculos vel tantum feminas generant." (Florian, 1875; Tarrasch, 1898.)

Naples. Bibliotheca Nazionale, Codex I-VIII-D. 53 (fourteenth century). Anatomia Alberti. "Galienus testatur in tegni quod quicunqui . . . tantum generant masculos vel tantum feminas, prout virga virilis torquetur ad illam partem. Explicit Anatomia Alberti; id est divisio omnium membrorum." (Redeker, 1917.)

VARIANTS

London. British Museum, Additional Manuscript 24069 (beginning of thirteenth century). Anatomia Magistri Nicolai physici. "Sicut testatur Galienus, Si quis dispositionem membrorum intrinsecorum et extrinsecorum . . . et soliditatem matricis non defacili accenduntur, sed accensae tarde relinquunt." (Redeker, 1917.)

Oxford. Bodleian, Codex Ashmole 1398 (thirteenth century). Anatomia Ricardi. "Gallieno attestante in tegni . . . et inde nutrimentum omnium membrorum habent commune." (Redeker, 1917.)

Contents and Sources

As will be seen from the translation, the work differs widely from those previously discussed. It is in the first place a systematic descriptive anatomy, dealing with all parts of the body in logical sequence rather than in an order dictated by convenience of dissection. It purports to describe the human body, rather than the pig. Moreover, the subject-matter is handled in a highly organized style, much space being devoted to definition, classification, and arrangement of the material. The whole tone of the book suggests the philosophical method of scholasticism, though in the Ricardus and Nicolaus texts this style is not so far developed as in later works, say of the thirteenth and fourteenth centuries.

The *Anatomia Nicolai* is longer and more complete than the *Anatomia Ricardi,* but the latter is not simply an abridgment of Nicolaus, for it contains numerous passages of different wording. Redeker, after a lengthy comparison of both these texts and of the variants found in such manuscripts as that of the Ashmolean collection, has been unable to trace a definite sequence of the various texts, nor has he found any common source from which all the rest might have been compiled, and therefore he falls back upon the not improbable hypothesis that the texts as we have them were prepared by the writing down of lectures from oral delivery. The text of Nicolaus is probably nearer to the hypothetical original than the others, which presumably introduce the sort of errors, omissions, and variations characteristic of inaccurate reporting.

An examination of the texts shows that they are derived from Constantine's *Pantegni,* as was first pointed out by Töply in his *Studien* (1898). The vocabulary is unmistakable, and the order of arrangement of the descriptions closely follows Constantine. However, I do not find whole passages or even sentences taken from Constantine, as in the Second Salernitan Demonstration; rather, the text is compiled and condensed from the *Pantegni,* and made more classificatory and more systematic. It tends to list rather than to describe the structures.

I agree with Redeker that there is no suggestion of Stephen of Antioch's translation of Ali Abbas in these early mediaeval texts; nor do I see evidence of influence from the Latin versions of Rhazes and Avicenna, which were made late in the twelfth century. The authors quoted in Nicolaus are the *Pantegni;* the *Prognostics, Aphorisms,* and *Airs, Waters, and Places* of Hippocrates; the *Book of Urines* and the *Diets* of Isaac; Galen's *Tegni,* and Theophilus. There are also two quotations from Aristotle, one via Isaac and one purporting to be direct. In Ricardus, but not in Nicolaus, the *Viaticum* is also quoted, and in the Ashmolean manuscript the *Isagoge* of Johannitius. With the exception of the one direct quotation from Aristotle (which perhaps is after all from some intermediate source) and perhaps the *Airs, Waters, and Places,* all of these books are found among the Constantinian translations or are known to have existed in early Salernum.

Probable Date

From the paleographic characteristics of the manuscripts we know that these existed in the earlier part of the thirteenth century. Furthermore, since, as Ferckel (1913) has shown, there are numerous quotations from Ricardus in the *Speculum Naturale* of Vincent of Beauvais, we may be certain that these anatomical texts were prepared between the *Pantegni,* about 1080, and the *Speculum Naturale* about 1250. Finally, their dependence upon Constantine and their freedom from later influences strongly suggest an origin in the twelfth century, and even hint that they belong to the Salernitan School in place as well as in time of origin. As to their authors we know nothing. Magister Nicolaus can not be identified with any physician of that name, while the association of the name of Ricardus with one of these texts rests upon very slight grounds to be discussed below (page 41).[1]

Scholasticism in Mediaeval Anatomy

Readers who have followed the older work on the *Anatomia Ricardi* (*Salernitani*) will notice that the preceding dating of this book is in disagreement with Florian and Tarrasch and with Pagel (Handbuch, Bd. 1, S. 703), all of whom placed the book in the "scholastic period," by which they mean the fourteenth century. Such a disagreement reflects a confusion of thought which (as one knows from experience) is common and misleading, and justifies us in a brief digression on the subject of scholasticism in mediaeval medicine. Here again acknowledgment must be made to the dissertation of Redeker, who has put the explanation in very clear terms. Combining Redeker's reflections with our own, we may begin with a definition of scholasticism, which is (to borrow from Archbishop Keane):

> "A method, a style, a manner of handling certain truths, which contrasts strongly with their treatment in times previous or posterior to the period in which scholasticism flourished. This method is highly technical, didactic, analytic, implying a severe and exact use of the reasoning faculties. It is strictly syllogistic, and tends to present the doctrines of . . . philosophy in a complete methodical system, in which an even balance and a due proportion shall everywhere be observed. . . . It has been made a reproach to the scholastic period that it examined with excessive subtlety, and was marked by an arid formalism, infinite prolixity of treatment, barbarous technology, etc."

Such a method of treating the questions of religious philosophy and metaphysics reached its apogee in the fourteenth century as a result of the spread of Aristotelian philosophy following the great period of translation from the Arabic and Greek at Toledo and elsewhere in the early and middle thirteenth century. At this time European scholarship was

[1] Dr. Charles Singer, after reading this work in manuscript, has made the ingenious suggestion (which he has convincingly demonstrated by writing out the names, Nicolaus and Ricardus, in the Beneventan script) that a very slight blurring of the writing might result in altering the former name into the latter.

put in possession of the whole fruits of a movement which had flourished in the Orient for centuries, and Aristotle became the foundation of religious philosophy, while Averrhoes and Avicenna provided a basis for scientific scholasticism. On account of the more or less sudden advance thus made in religious and metaphysical method, it is customary to think of the "scholastic period" as beginning in the thirteenth century.

It has not been sufficiently understood, however, that the translations of Constantine and the School of Salernum gave the Occident some of the fruits of Oriental scholasticism in medicine a hundred years before the later Arabic philosophers and physicians were translated at Toledo. Medical writers could and did learn the rudiments of scholastic method from the *Pantegni* and the *Isagoge,* and therefore the appearance in the *Anatomia Ricardi* of a highly didactic style, an elaborate system of classification, and the beginning of an artificially explanatory and argumentative method, is perfectly compatible with the composition of this work in the latter part of the twelfth century.

On the other hand, a descriptive science like anatomy does not lend itself to the extreme ratiocination reached in other branches of learning during the height of the movement, and therefore such texts as the *Anatomia Vivorum,* next to be discussed, or even still later works like Mondeville's *Anatomy,* though they fulfill both the definition and the reproach we have quoted from Keane, do not, however, reach the limits of scholastic method. Earlier texts are likely to exhibit more of the scholastic style, later texts less, than philosophical books of the corresponding periods. For these reasons the "scholastic manner" is an uncertain guide in determining the age of a medical document.

A THIRTEENTH-CENTURY TEXT

Anatomia Vivorum (Anatomia Ricardi Anglici)

The highly interesting text which concludes our series of anatomical works of the period 1080 to 1250 A. D. is best known through the edition of R. v. Töply (1902), who found it in a fifteenth century manuscript of the Palatine Library at Vienna (No. 1634), in company with a group of medical works headed by the name of Ricardus Anglicus. Töply supposed himself the discoverer of the text, and printed a very exact transcription, with valuable notes. He might not have undertaken this labor, so useful to modern students, had he been aware that the same text had already been in print for about 350 years. It is, in fact, identical in all but a few verbal details with the book called *De Anatomia Vivorum,* which was among those gathered together and printed by the too-generous sixteenth- and seventeenth-century editors of Galen, from Giunta and Froeben to Charterius. Somewhere in his authentic writings Galen refers to a book of his own composition on the anatomy of the living, and the first editors perhaps assumed that this was what they were printing, in spite of the fact that it contains references to Avicenna and Isaac, which should have enlightened even the most uncritical of Renaissance editors. None of the known manuscripts call the book *Anatomia Vivorum,* and there is no particular justification in the book itself for such a title. However, I shall use that name in this account in preference to *Anatomia Ricardi Anglici* (for which, as we shall see, there is no authority at all), in order to avoid any further confusion with the work *Anatomia Ricardi* (*Salernitani*).

The text is so obviously important for the history of the period between Salernum and Bologna that it has been disappointing to have no manuscript earlier than the fifteenth century. For this reason I undertook in 1924 a deliberate search for other and earlier manuscripts. The British Museum catalogue revealed, in MS. Sloan 59, another fifteenth-century copy headed by the title *Liber Anatomiae que Aristotelis dicitur.* A third claimant for the authorship!

Finally, a suggestive entry in the list of manuscripts at Chartres led me to visit that too-little-known library, where I had the pleasure of examining a hitherto unknown copy of this book, which is two centuries older than the other copies and which must have been written out within a generation or two of its author's lifetime.

This manuscript is found in the Bibliothèque Publique de Chartres, where it is MS. No. 284, *Galieni Opuscula.* It is a well-preserved parchment book of the thirteenth century. On the first leaf there is a table of contents in an old hand, and on the reverse a paragraph of crabbed

and practically illegible writing a century or two later than the book, of which the first line reads "iste liber est magistri Nicolai de Azola medici." At the top of the second leaf in an eighteenth-century hand is the note "ex bibliotheca capitoli Carnotensis." The book contains 266 leaves, three at the end having been excised; the text, which is written in a very regular small hand, runs continuously throughout the volume, one book beginning on the line next after completion of the previous book, indicating that the volume was written as a whole from beginning to end. Each book is headed by a handsome initial letter in gold and colors, and in some of the books, including the *Anatomia,* the chapters are headed by very neat small initials in blue and red. Where these occur there are marginal decorations consisting of lines and scrolls in blue and red, some of them containing small heads of animals. All these details suggest that the text was considered worthy a skillful scribe and was prepared for a client of taste and means.

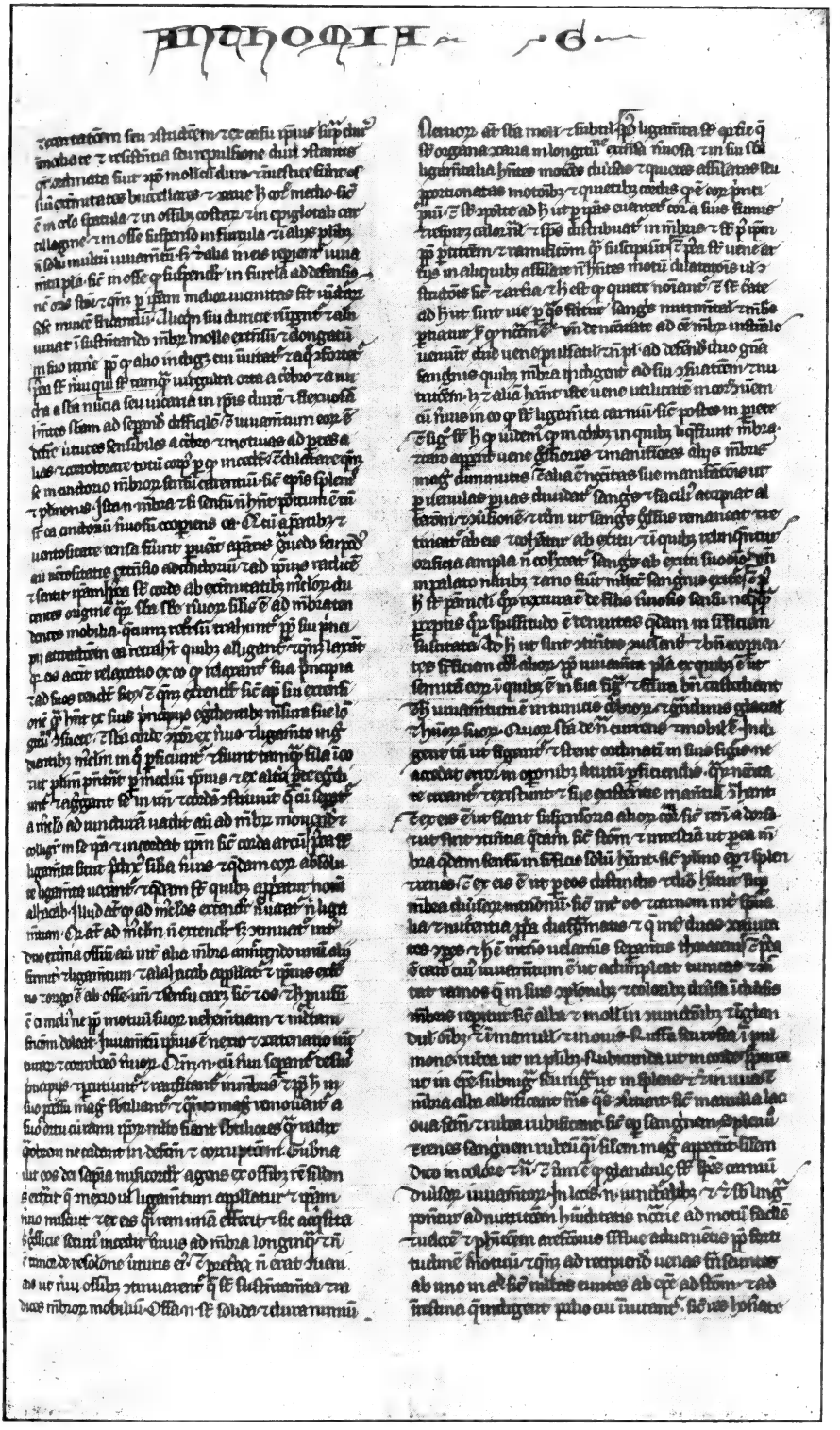
In determining the age of this manuscript I have had the friendly advice of Dr. Charles Singer and Professor C. H. Haskins, both of whom are disposed to place it at about the middle of the thirteenth century, without excluding the possibility of origin at any time between 1250 and 1300.

The table of contents is as follows:

1. Liber de elementis.
2. " complexionibus.
3. " simpliciis medicis.
4. " malitiae complexionibus diversae.
5. " iuvamento membrorum.
6. " ingenio sanitatis.
7. " tactu pulsium.
8. " motibus liquidis.
9. " voce et anhelitu.
10. " anatomia.
11. " morbo accidente.
12. Mega Tegni.
13. Liber de interioribus membris.
14. " criticis diebus.
15. " crisi.
16. " spermate.
17. " secreta Galieni a magistro Girardo Cremonensi translata de arabico in latine verba Galieni.

The volume is therefore a collection of some of the smaller books of Galen, with a number of others incorrectly ascribed to him, some of them no doubt translations from the Arabic and others compilations made in Europe, the whole forming just the kind of omnium gatherum that went under the name of Galen from the twelfth century on through the Renaissance.

The anatomical portion runs from folia 139 verso to 149 verso, beginning "Incipit lib. Galieni de anathomia. Medicorum anatomicos necesse est praecognoscere quod humanum corpus cum sit compositum . . ."



A page of the earliest known manuscript of the *Anatomia Vivorum*, Chartres, Bibliothèque Publique, No. 284, fol. 140, recto. About three-fourths actual size.

and ending "et proximum est hepar et ita patet diversitas inter G. et Ar. Explicit anatomia." The text resembles the printed *Anatomia Vivorum* (pseudo-Galeni) almost literally, with only three or four trifling differences in titles and headings of the chapters. The pseudo-Galenic text, however, differs from that of Töply's manuscript in several particulars; it has a number of Latin words where the manuscripts have Arabic terms; its readings are sometimes more intelligible than those of the manuscripts, and there is a slight difference in arrangement, the section on the veins and on phlebotomy (sec. 43 in Töply) being placed in the pseudo-Galenic text before the passage "de anatomia membrorum consimiliorum."

Sources of the Anatomia Vivorum: Avicenna and Rhazes

Having obtained from the characteristics of the Chartres manuscript fairly definite proof that the text is hardly later than the middle of the thirteenth century, we may proceed to determine its earliest possible date of composition, first examining the text itself for evidence of its sources. In this our author has aided us by making a number of citations from well-known authors, namely, Aristotle, Avicenna, Galen, Hippocrates, and Isaac.

Among the fruits of the great activity in translating from the Arabic which centered at Toledo at the end of the twelfth century were Latin versions of two more of the comprehensive cyclopaedias of medicine which were a characteristic product of the Arabic culture. Gerard of Cremona's translation of the *Canon* of Avicenna was made some time between the years 1170 and 1187. Such was the favor accorded Gerard's work that his version has never been superseded; from manuscript it went into print about fifteen times before 1500 and often thereafter. Later editors did not much revise the text, and therefore it happens that we now have at hand the same version from which the compiler of *Anatomia Vivorum* made his citations.

The *Khitaab-al-Mansuri* of Rhazes was also translated about the same time, perhaps also by Gerard, and became one of the chief text-books of mediaeval medicine under the latinized name *Liber ad Almansorem.* Like the *Canon,* this twelfth-century translation was preserved and printed many times. In the work of Rhazes the anatomical material forms a separate chapter, the first in the book. It is a brief systematic description of the bodily tissues and organs, compiled from Galen, Hippocrates, and Oribasius (as shown long ago by Freind, 1725–1727) without original additions and of course without evidence of any examination of animals. The anatomical descriptions of Avicenna, compiled in the same way from the ancients after the example set by Rhazes and Ali Abbas, are not found in a single chapter set apart for anatomy, but are scattered through the vast reaches of the *Canon.* In Koning's useful French and

Arabic edition of the three chief Arabic anatomies, Avicenna's anatomy is gathered into one treatise, in which it may easily be compared with its two predecessors.

Töply, the first modern editor of *Anatomia Vivorum,* realized that his text was based largely upon Avicenna, but he did not look farther into its sources. To this first step I can now add an analysis which goes far toward explaining its history. The *Anatomia Vivorum* contains long passages from Avicenna and a smaller number from Rhazes; and all these passages are copied verbatim from Gerard of Cremona's translation of the *Canon* and from the ancient translation of Rhazes. These we may list as follows, the numbers referring to the chapter of Töply's edition:

1. Introduction. Not from Avicenna or Rhazes.
2. De membris consimilis. Many sentences from Canon, Lib. 1, Fen. 1, Doct. 5, Cap. 1.
3. De nervis. Almost literally from *ibid.,* Cap. 1, and Cap. 1, summa.
4. De cordis. From the same, but not quite verbatim.
5. De ligamentis. *ibid.,* Cap. 1.
6. De arteriis. *ibid.,* slightly reworded.
7. De venis. The first part of this passage is from the same, slightly reworded.
8. De panniculis. From the same with many verbal changes.
9. De carne. The first lines are from the same.
10. De adipe, and
11. De medulla. Corresponding passages not found in the Canon; based in part upon a suggestion in Aristotle, Hist. Animalium, Lib. III, Cap. XVII.
12. De mollicie et duricie. A short passage on the humors of the eye, probably interpolated.
13. De nucha. Interesting theoretical section not found in the Arabic sources, but incorporating an idea from Aristotle, Partes Animalium, Lib. II, Cap. VI.
14. De virtutibus, ortu et structura membrorum simplicium,
15. De vasis,
16. De cute,
17. De organicis membris,
18. De felle,
19. De ossibus, etc.,
20. De principalibus membris, and
21, 22, 23, 24, De corde. These sections are all compiled from the various sources, quoting Galen, Aristotle, and Isaac, but without long verbatim excerpts.
25. De arteriis cordis. Follows literally at first Avicenna, Lib. 1, Fen 1, Doct. 5, Cap. 1. Then describes lung, following *ibid.,* Fen 10, Cap. 1.
26. De compositione oculi. Suggests Avicenna.
27. De auribus. Begins literally from Avicenna, then deviates.
28. De nasi. Reminiscent at first of Avicenna.
29. De ore. Largely uses words of Avicenna, Lib. 3, Fen 6.
30. De dentibus.

31. De uva.
32. De meri.
33. De stomacho.
34. De compositione stomachi.
35. De pluribus vasis secum.
36. De epate.
37. De pluribus vasis.
38. De colatoriis.
39. De vesica. Sections 30 to 39 do not make use of the exact words of Avicenna nor of Rhazes.
40. De matrice, etc. Reminiscent throughout of Avicenna.
41. De quo creatum sit cor. The first sentences reworded from Avicenna.
42. De operationibus ab anima procedentibus. A compilation, based in part on quotations from Aristotle.
43. De viginti paribus nervorum. This section is a cento made of the two Gerardine translations, being taken verbatim from Rhazes ad Almansorem, Tract. 1, Cap. 5, and from Avicenna, Lib. 1, Fen 1, Doct. 5 (Summa 3), Cap. 3.
44. De venis. The first paragraph is verbatim from Rhazes, loc. cit., and the second part is largely from Avicenna, Lib. 1, Fen 4, Cap. 20 (partly verbatim).

Date of the Anatomia Vivorum

The fact that our author has compiled his book so largely from the Gerardine translations proves of course that the *Anatomia Vivorum* is subsequent to them in date, and can not have been compiled before 1180 at the earliest. On the other hand, the latest possible date is determined within a decade or two by a discovery made by Ferckel (1912, 1913) that Thomas of Brabant (Thomas de Cantimpré), in his encyclopaedic work *De Naturis Rerum,* made about 22 excerpts from the *Anatomia Vivorum.* One of these excerpts, which is from the section on the uterus, was printed by Ferckel in his book of 1912, but the others are merely mentioned in his later paper, and I have not been able to verify them for want of a copy of *De Naturis Rerum,* which exists only in manuscript. Ferckel's specimen passage is a verbatim quotation of ten or twelve lines from *Anatomia Vivorum,* introduced by the words "Galen dicit"; according to Ferckel all of the excerpts are ascribed to Galen.

There can be hardly any doubt, therefore, that the *Anatomia Vivorum* was in existence at the time *De Naturis Rerum* was written, namely, about the year 1225 or not later than 1240. In the hope of still further narrowing the limits of 1180–1240 thus arrived at, I have devoted some labor to the citations from Aristotle which occur a dozen times in the book. Most of these refer to readily discoverable passages in *De Partibus Animalium* and *De Generatione,* in sufficient detail to suggest that the author had access to a copy of those works in Latin. The researches of Jourdain (1843), unchanged by Grabmann's later work (1916), have revealed only two early translations of Aristotle on Animals. One

of these was made by Michael Scot at Toledo at a date not later than 1236 and perhaps as early as 1210–1225. This was made from an Arabic version. Later (about 1260), William of Moerbeke prepared another translation directly from the Greek. Neither has been printed, but both exist in manuscript.[1] On the authority of Camus (1801) and of Jourdain, the MS. lat. 6989 (ancien fonds) of the Bibliothèque Nationale is a copy of Scot's translation, and No. 14724 (formerly listed Fonds de Saint Victor, No. 333) is the Graeco-Latin translation. From a brief comparison of the quotations in the *Anatomia Vivorum* with the original texts in these two manuscripts I believe that neither had been copied verbatim by our anatomical compiler. However, Scot's translation is at present the only known Latin version of Aristotle on Animals which was available before 1240. Unless our author had in some way had access to the Arabic, or had a Latin source which has escaped notice, we must assume that he was merely quoting from Scot's Aristotle, but in a paraphrastic way. If this be the case, the date of our anatomical text lies between the years 1210 and 1240, probably about 1225.

About the same time, another author was engaged in a similar though greater compilation from the same sources. This was Albert Graf von Bollstädt, Albertus Magnus, whose vast cyclopaedia of all knowledge includes a review of natural history (learned edition by Stadler, 1916). The work is a sort of free rendering of Aristotle's Natural History, interlarded with excerpts from Avicenna, Rhazes, and other writers and bound together by the editorial comments of Albertus himself. A comparison of the anatomical chapters with the *Anatomia Vivorum* shows that the two writers often select the same passages from their authorities, but not in exactly the same words. In their chapters on the nerves, for instance, Albertus (Lib. 1, Tract 1, Cap. 1) follows Avicenna only, while *Anatomia Vivorum* combines Avicenna and Rhazes, but copies the words of Avicenna more closely than does Albertus. *Anatomia Vivorum* takes passages from Avicenna which are not in Albertus, for example, Section 44, de phlebotomia. The quotations from Aristotle are not in the exact wording used by Albertus.

The two works resemble one another particularly in the fact that both devote much attention to expounding the differences between Aristotle and Galen as to the origin of the veins and the relative importance of the heart in comparison with the brain and the liver. Both deal with the problem in exactly the same way, citing first the views of Aristotle,

[1] Stadler has in effect given us a printed edition of Michael Scot's version of Aristotle on Animals, since in his great edition of Albertus Magnus, the passages which Albertus copied literally from Scot are all specially indicated. I did not learn of this indirect way of getting at Scot's version until after my examination of the manuscripts, but study of Stadler's text merely confirms the statement made above.

then Galen's dissenting opinion, followed by the teaching of Avicenna, and finally asserting their own concurrence with Aristotle.

In short, the *Anatomia Vivorum* is certainly not an abstract from the work of Albertus, which it seems indeed to antedate by a decade or more; but the two books reflect the same influences so plainly that one is tempted to suggest some sort of vague relation between them. Sudhoff, in his *Handbuch* (1922), considers the *Anatomia Vivorum* an early work of the Bolognese school; but I am more inclined to the hypothesis that the book was composed in the North, perhaps at Paris or in western Germany, by a pupil of one of the Dominican cloister schools in which Albert the Great lectured after his removal from Padua.

Wherever composed, and whoever the author, this little compendium of anatomy is one of the very first books of the Middle Ages to show the influence of the Aristotelian biology. In this sense it marks one of the turning-points in the history of thought.

Ricardus Salernitanus and Ricardus Anglicus

The persistent association of the name "Ricardus" with two of the early mediaeval anatomies demands discussion here, although the data are too meager to permit a solution of the problem. All the accounts of the two Richards in recent historical literature can be traced back to three sources. In the first place, Giles de Corbeil (Aegidius Corbolensis), who taught in Paris about the beginning of the thirteenth century, mentions in his well-known medical poem a physician named Richard, an old man who had been his teacher. He seems to say that he knew this man at Salernum, but, if the punctuation be shifted, as it is in some editions, the reference is then to Montpelier, and therefore, as Littré has pointed out, we are not even perfectly certain that there was a Richard at Salernum. No such name is found in the *Liber Confratrum.* The anatomical text which we call *Anatomia Ricardi* (*Salernitani*) does not bear the name of Richard in all the manuscripts. As shown in the list (page 31), it was variously ascribed during the thirteenth and fourteenth centuries to Galen, to a Richard, to an Alan, to an Albert, and to an anonymous writer. Finally, a manuscript of the Bibliothèque Nationale, *Ancien Fonds,* No. 7056, ascribes the book to Ricardus Anglicus. To Vincent of Beauvais, who quoted it freely in his *Speculum Naturale* (see page 33), this book was anonymous, since Vincent always refers to "libro de anathomia" or "libello de anathomia." The choice of the name Richard among all these possibilities as the title used by modern historians is due to the chance that the Berlin manuscript, from which it was first printed by Florian, bore the name Anatomia Ricardi. Töply (1898) was the first to suggest that this Richard was none other than the teacher mentioned by Giles de Corbeil. Hence the full title, *Anatomia Ricardi* (*Salernitani*), which serves now to distinguish this book,

although we are far from certain that a Richard wrote it, nor that it was written at Salernum, nor even whether there was a Richard at Salernum.

The second source of information about the name Ricardus is found in the chronicle of Matthew Paris, who says (Giles's translation, 1853):

"About the same time (1252) died Master Richard de Wendover, a canon of St. Paul's at London, and a physician of great renown. This man took precautions for himself in a much more prudent way than the above-mentioned Robert, for he provided the necessary means for nine priests to make a salutary offering to Christ forever, for the preservation of his soul. We have thought proper to make special mention of him in this book, because in his spontaneous devotion he bequeathed to the church of St. Albans a cross. . . . This cross had formerly belonged to Pope Gregory, who set the greatest value on it, and as the aforesaid Master Richard had been that Pope's physician, the latter when at the point of death gave what had been an object of the greatest regard to him, namely, this same cross, to his dearest friend, Master Richard."

Apparently no one has searched the Italian records of the time of Gregory IX for further information about Master Richard. The surname "de Wendover" seems to me open to doubt, because there was another man of the same period known in history as Magister Ricardus de Wendovre (de Wendene, de Wenden); he was elected Bishop of Rochester in 1235, after a dispute with the archbishop, died in 1250, and was buried in Westminster Abbey. He is mentioned many times in Matthew's chronicle, a few chapters before the Richard who was Gregory IX's physician, and it seems likely to the writer that Matthew Paris or some copyist of his book inadvertently attached the name of Wendover to the canon, thinking of the bishop.

The third source from which present-day writers take an item about Richard is the hand-book of literary history, *De Rebus Anglicis* of Pits (Johannes Pitsius, 1619). Pits says of Ricardus Anglicus that he studied at Oxford and at Paris and became a skillful physician and an accomplished medical writer. He flourished about the year 1230. No authorities for these statements are cited, but a list of his writings is given from a manuscript of Peterhouse College, Cambridge.[1] Following Pits, the statement that Ricardus Anglicus studied at Oxford has become part of the standard tradition. The books which are attributed to Ricardus Anglicus in the manuscripts include *De signis morborum, Summa de criticis diebus, De repressionibus,* and several others, including an anatomy. These books have never been carefully studied from the

[1] I have found an earlier reference to Ricardus Anglicus, in the medico-historical list of Symphorien Champier, "De medicine claris scriptoribus in quinque partibus tractatus," (Lyons, 1506?), which, although not very illuminating, may be given here for the sake of completeness: "Ricardus anglicus vir in medendis corporibus clarissimus et eruditus multa in medicines opuscula composuit. E quorum numero subjecta feruntur: de flebotomia lib. i., de anatomia lib. i., de signis pronosticis lib. i., de urinis lib. i., de aliis adhuc nihil vidi."

historical standpoint, and the list is therefore confused and uncertain. A critical examination and analysis of all the manuscripts is much to be desired. Meanwhile, there is no positive evidence to connect any known anatomical text with the name of this man. The only manuscript bearing the name of Richard with the surname Anglicus is that of Paris, lat. 7056, and this is actually a specimen of the older text, *Anatomia Ricardi* (*Salernitani*), which, as we have seen, can hardly be the work of a man who lived in the schools of Italy or Paris in the third decade of the thirteenth century.

Furthermore, Töply was unjustified in ascribing the *Anatomia Vivorum* to Ricardus Anglicus, even though the table of contents of the manuscript lists it as *Anatomia Ricardi.* Sudhoff (1914) has shown by a reexamination of the volume that the anatomy itself is anonymous, but that the name of Ricardus was attached to it in the table of contents by the error of a cataloguer of about the year 1400, who imagined that a whole series of books at the beginning of the volume belonged to Richard because the first of them bore his name. The Chartres manuscript is anonymous, though it occurs in a volume of Galenic and pseudo-Galenic writings. To Thomas of Brabant, who used the text in 1240 or earlier, it was known as the work of Galen.

We have, then, as evidence for the name and anatomical work of Richard, (1) Giles de Corbeil's eulogy of a twelfth-century teacher of that name; (2) a twelfth-century anatomical text sometimes ascribed to Richard, sometimes to other names; (3) the record of Pope Gregory's physician, who was a Master Richard and apparently an Englishman; (4) a late and unauthoritative statement of Pits about a Ricardus Anglicus who studied at Oxford and Paris about 1230; (5) a number of therapeutic and diagnostic works, probably of the thirteenth century, constantly associated with the name of Ricardus Anglicus; (6) an anatomy of about 1225 A. D. ascribed by fifteenth-century error and twentieth-century conjecture to Richard the Englishman. Let the reader fit together these fragments of the puzzle according to his own judgment. It seems not unlikely that the supposed Salernitan Richard of Giles de Corbeil and the Richard of Italy, of Paris, and of England were actually one and the same. In any case, caution suggests that we leave to Richard the Englishman the reputation of his clinical writings alone, while denying him present honor as the author of *De Anatomia Vivorum.* Nine priests said mass in St. Alban's Cathedral for the peace and honor of Richard; as for the other, we know neither his name nor his fate, but his memory will be cherished by the whole company of anatomists, witnessing him the first of their number who sought to restore the spirit of Aristotle.

TABULAR SUMMARY

ANATOMICAL TEXTS OF THE EARLIER MIDDLE AGES

1. Anatomia Cophonis (First Salernitan Demonstration).
   "Quoniam interiorum membrorum corporis humani compositiones omnino ignotae erant."
   Date: about 1100–1150.
   Chief Sources: Constantine's translations of the Pantegni and of the Aphorisms of Hippocrates.
   Manuscripts: Munich, Hofbibliothek, Lat. 4622, twelfth century; Paris, Bibl. Nat., Lat. 7030A, fourteenth century; Paris, Bibl. Nat., Lat. 7036, fourteenth century, and others.
   Printed editions: In Divi Mesue Vita, 1531, and other sixteenth century editions of Mesue; in sixteenth century complete editions of Galen; in Dryander, Anatomia, 1537; in Severino, Zootomia, 1645; in De Renzi, Coll. Salern., 1854.
2. Second Salernitan Demonstration.
   "Corporis animalis machinam et compaginem universam membra varia et diversa."
   Date: about 1100–1150.
   Chief Sources: Constantine's translations of the Pantegni and of the Aphorisms of Hippocrates.
   Manuscripts: Breslau, Stadtbibliothek, MS. 1302, twelfth century (ca. 1170); Erfurt, Amploniana, Codex 204, twelfth-thirteenth centuries.
   Printed editions: In De Renzi, Coll. Salern., 1854; Benedict, 1920.
3. Anatomia Mauri.
   "Quoniam humani corporis noticia exparcium incipit cognitione."
   Date: probably about 1100–1150.
   Chief Sources: Constantine's translations of the Pantegni and of the Aphorisms of Hippocrates.
   Manuscript: Rome, Vatican, Pal. lat. 1097, twelfth century.
   Printed edition: Ploss, 1920.

4*a*. Anatomia Ricardi (Salernitani).
   "Galieno testante in Tegni quiscumque interiorum membrorum corporis humani dispositionem scire desiderat."
   Date: twelfth century.
   Source: Constantine's Pantegni.
   Manuscripts: Würzburg, Univ. Bibliothek, m. p. q. 1, thirteenth century; Berlin, Kaiserliches Bibliothek, "in a fourteenth century MS. of Lanfranc," and numerous others (see list, p. 31).
   Printed editions: Florian, 1875; Tarrasch, 1898; Schwarz, 1907.

4*b*. Anatomia Magistri Nicolai physici (a variant of Anat. Ricardi Salern.).
   "Sicut testatur Galienus, si quis dispositionem membrorum intrinsecorum et extrinsecorum in corpore humano scire desiderat."
   Date: twelfth century.
   Chief Source: Constantine's Pantegni.
   Manuscript: London, British Museum, Additional MS. 26069, early thirteenth century.
   Printed edition: Redeker, 1917.

5. Anatomia Vivorum (Anatomia Ricardi Anglici).
   "Medicorum anatomicos necesse est procognito scire quod humanum corpus sit conpositum."
   Date: about 1225.
   Chief Sources: Gerard of Cremona's translations of Rhazes and Avicenna; and an unidentified Latin version of Aristotle's Natural History.
   Manuscripts: Chartres, Bibl. Publique, No. 284, thirteenth century; Vienna, Bibl. Pal. No. 1634, fifteenth century; London, British Museum, Sloane 59, fifteenth century.
   Printed editions: In sixteenth century complete editions of Galen; Töply, 1902.

Since the preparation of this summary, Campbell's *Arabian Medicine and Its Influence on the Middle Ages* (London: Kegan, Paul, Trench, Trubner & Co., 2 vols., 1926) has appeared. The second volume of Campbell's work contains an extensive list of manuscripts of all the works attributed to Galen in the Middle Ages (taken from Diels), together with certain indications as to printed editions. The list includes (vol. 2, pp. 138–139) five manuscripts of the *Anatomia Vivorum* not mentioned in the present work, none of them as early, however, as Chartres No. 284. On pages 137, 138 there is a long list of manuscripts under the title De Anatomia. From the list it is not possible to know exactly what these are, but no doubt many of them are copies of *Anatomia Ricardi* (*Salernitani*). Campbell's entry (page 138), implying that this text has been printed in the Frellonius *Opera Galeni* is misleading, since the page cited proves actually to contain the *Anatomia Parva* (*Cophonis*). Campbell states, without citations or other evidence, that Greek and Arabic manuscripts are known; but if the Latin manuscripts of his list are what they seem to be, it is certain that they can not have *antecedent* Greek or Arabic versions.

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REVISED LATIN TEXT OF THE ANATOMIA PORCI (COPHONIS)

The following text is based on that of Severino as reprinted by De Renzi. The insertions and alterations, which are distinguished by parentheses, are derived from the various other sources as indicated by footnotes.

Quoniam interiorum membrorum corporis humani compositiones[1] omnino erant ignotae placuit veteribus medicis et maxime Galeno ut per anatomiam brutorum animalium interiorum membrorum positiones[1] manifestarentur. Et cum inter bruta animalia quaedam ut simia in exterioribus nobis inveniuntur similia, interiorum partium nulla inveniuntur adeo similia ut porci, et ideo in eis anatomiam fieri destinavimus. Est autem anatomia recta divisio, quae sic fit: porcum debes inversum ponere, quem per medium gutturis incides, et tunc primum tibi lingua occurret, quae dextrorsum et sinistrorsum quibusdam nervis alligata est, qui motivi dicuntur. (Et ad ipsam linguam ab inferioribus nervis veniunt quidam nervi qui reversivi dicuntur)[2] quod cum ipsi a cerebro veniant ad pulmonem revertuntur ad linguam, per quos lingua movetur ad voces. Ibi iuxta sunt carnes glandulosae, quae dicuntur pharynges, et eorum inflatio similiter dicitur: sunt etiam ibi maximae glandulae, in quibus colligitur humor et facit branchos. In radicibus linguae oriuntur duo meatus, scilicet trachea arteria, per quam transit ad pulmonem aer, et oesophagus, per quem mittitur cibus ad stomachum; et est trachea arteria super oesophagum, super quam est quaedam cartilago, quae dicitur epiglottis, quae clauditur aliquando ut cibus et potus per eam non descendat et aperiatur ut aer intret et exeat. Inter tracheam arteriam et oesophagum est locus qui dicitur isthmon, inter duo[3] praecipitia, in quo aliquando humor colligitur et facit apostema quod dicitur angina; aliquando pars est intra et pars extra et dicitur squinantia; aliquando totus extra et dicitur synantia.[4] Tunc debes separare tracheam arteriam ab oesophago et invenies pulmonem et cor. Cor vero est magis in sinistra parte (et pulmo in dextra)[5] quorum quilibet in sua capsula continetur. In capsula cordis colligitur materia, quae facit syncopen; in capsula pulmonis colligitur materia quae facit peripneumoniam. Et tunc videbis quandam venam quae concava dicitur, quae ab hepate venit per medium diaphragmatis et subintrat inferiorem auriculam cordis et

[1] Severino and Pseudogalen have: *partes.*
[2] Inserted from Codex Monacensis lat. 4622.
[3] Cod. Monac. has: *dura.*
[4] This clause follows Cod. Monac. and Pseudogalen; the Divi Mesue Vita and Severino texts are defective.
[5] Inserted from Pseudogalen.

fit arteriam de qua fiunt omnes aliae arteriae quae procedunt ad membra, in quibus fiunt pulsus, quibus mediantibus cor alligatum est pulmoni (et aerem trahit a)[1] fistulis pulmonis, in quibus colligitur humor quae facit sansugium; aliquando colligitur extra eas et facit anhelitum, aliquando intus et extra et facit orthomiam. Et quod pulmo sit cavernosus [2] potestis probare si cum calamo intromisso infletur. Sub illis membris est panniculus qui dicitur diaphragma, qui dividit ea ab nutritivis, qui coniungitur teneritatibus costarum, in quibus colligitur humor qui facit pleuresin. Tunc debes reverti ad nutritiva et computa longitudinem oesophagi ad usque septimum spondyle, et incipit os stomachi supra diaphragma, stomachus vero inferius. Sub stomacho est intestinum quod dicitur portanarium, sub portanari est duodenum, sub duodeno est ieiunum, sub ieiuno est orbum, sub orbo saccus, sub sacco longaon, et sunt ibi quaedam gracilia intestina, quae lateralia vocantur, in quibus est iliaca passio. Ex dextra parte sub fundo stomachi est hepar positum, in cuius substantia est quaedam vesica, quae cystis fellis appelatur, et super hepar sunt duo panniculi, zirbus et siphac, qui sunt implicati velut rete. Quod apparet ibi pingue et grossum, dicitur zirbus; quod autem subtile est, siphac; quae procedunt usque ad splenem, per quos venae transeunt, per quas melancholia ab hepate ad splenem mittitur. Est autem splen membrum oblongum in sinistro latere positum. Loca quae sunt sub splene et hepate dicuntur hypochondria. Tunc debes omnia intestina extrahere, et tunc occurret tibi in medio spinae arteria magna, sub qua et vena magna continetur, quae arteria fit de omnibus arteriis capitis, quae condensantur in unam magnam arteriam, quae descendit a lumbos et a se varias arterias transmittit, tam dextrorsum, quam sinistrorsum ad inferiora. Vena ibi magna fit de venis capitis condensatis, quae venit usque ad renes, et bifurcatur, et ibi fit vena chilis in qua infiguntur capillares venae, quae prae nimia parvitate sua videri non possunt, per quas urina cum quattuor humoribus mittitur ad renes. (Sunt autem renes quaedam membra oblonga et concava in principiis lumborum posita).[3] Tunc invenies ibi duos meatus, qui uritides (pori)[4] dicuntur, et per eos resudat urina in vesicam. Nam ipsi infiguntur vesicae qui etiam transeunt per quendam panniculum, quo omnia intestina praeter longaonem clauduntur, qui vocatur epigorontysmeon [5] coli, quo rupto intestinum cadit in osceum, (supra quem est pinguedo quae vocatur omentum. Super omentum est siphac.).[6]

(The following paragraphs are not found in all the sources, see p. 20.)

[1] Inserted from Cod. Monac.
[2] Div. Mes. Vit. has: *caminosus;* Cod. Monac.: *carnosus.*
[3] Inserted from Cod. Monac., Pseudogalen, and Paris 7036.
[4] Inserted from Div. Mesue Vita and Cod. Monac.
[5] Pseudogalen has: epigome cinctus menon.
[6] Inserted from Cod. Monac. and Pseudogalen. Paris 7036 has: super omentum est sumen.

Nunc de anatomia matricis dicendum est. Sciendum est autem quod natura hoc membrum in mulieribus disposuit, ut quicquid in toto mense de superfluitate generaretur, ad hoc membrum in consueto tempore tanquam ad sentinam totius corporis mitteret: et inde mulieres naturaliter menstrua habuerunt. Est etiam hoc membrum ager naturae qui excolitur ut fructificet; in quo aliquando ut in bonam terram eiicitur, quod adhaeret in ea et per actionem cooperantis naturae calidae, et spiritu mediante inferius (infunditur more germinis);[1] et a se ramusculos emittit per quasdam radices vel ora quibus infigitur matrici, et per quae nutrimentum sibi ministratur et futuro foetui; et sic postea actione virtutum, ut saepe a me vobis dictum est, si bene recolitis, futurus foetus generatur, et augmentatur. Est autem posita matrix super intestina; et supra collum eius est vesica, et sub ea longaon est, et inferius est vulva. Tunc debes scindere matricem per medium os; ubi invenies duos testiculos superpositos, per quos sperma muliebris mittitur ad matricem ut ex eo et virili fiat foetus. Habet autem matrix septem cellulas; et si praegnans est, in ea foetum invenies, supra quem videbis quandam tunicam, quasi camisiam, quae secundina dicitur; quae rumpitur quando foetus recalcitrat ad exitum; quae alligata matrici et foetui venis per eam transeuntibus nutrimentum ad matricem et ad foetum transmittit; et illi meatus quibus foetus alligatur, dicuntur cotyledones. Est etiam ibi quidam magnus meatus, qui umbilicus dicitur, qui rumpitur iuxta matricem[2] in quantitate quattuor digitorum, ex cuius ligatura fiunt phlegmones in umbilico.

Nunc de anatomia cerebri videamus. Debes ergo in summitate capitis incidere, et remota cute invenies pelliculas quasdam, quae dicuntur musculi, sub quibus invenies os quod dicitur cranium; sub cranio est pellicula, quae dicitur dura mater, sub qua est pia mater, denique cerebrum. In oculis est tunica quae appellatur coniunctiva et apparet alba; quae est iuxta eam, aliquantulum est subnigra, et dicitur cornea; quae sub illa magis est nigra et minor, et dicitur uvea. Tunc incide per medium; et humor qui prius exibit, dicitur albugineus; qui post eum est, et coagulatus in modum crystalli, dicitur crystallinus; et qui ultimo est, ipse vitreus appellatur. Nervus qui ab interioribus venit ad oculum, qui est albus, et angustus, ipse dicitur opticus, et qui venit ad aures, dicitur auditorius nervus.

[1] Substituted for the unintelligible "scinditur in more gravis" of Pseudogalen, on the authority of MS. Paris 7030A.

[2] The Copho text edited by Schwarz gives the following reading, which is more intelligible than our text: . . . rumpitur iuxta matricem, cum foetus egreditur, et cum foetu exit, quem ligant obstetrices in quantitate IIII digitorum; ex cuius ligatura fiunt phlegmones. Paris 7030A has a similar passage ending "ex ligatura fiunt revolutiones umbilici" (!)

THE ANATOMY OF THE PIG, ATTRIBUTED TO COPHO

[Translated from the preceding revised Latin text]

Because the structure of the internal parts of the human body was almost wholly unknown, the ancient physicians, and especially Galen, undertook to display the positions of the internal organs by the dissection of brutes. Although some animals, such as monkeys, are found to resemble ourselves in external form, there are none so like us internally as the pig, and for this reason we are about to conduct an anatomy upon this animal.

The term *anatomy* signifies "correct division," which is performed as follows: place the pig on its back and incise its throat in the middle. The first thing which presents itself is the vocal organ,[1] which is bound on the right and the left by certain nerves, called *motivi.* Also there come to the vocal organ, from below, certain nerves which are called *reversivi,* because after proceeding from the brain to the lung they return to the vocal organ, by which means it is moved in producing the voice. Nearby there are fleshy masses called *pharynges,* and the same term is applied to swelling of these structures. There are also in this region large glands in which humors collect and cause tumor of the throat.[2] At the base of the tongue arise two passages, namely, the *trachea arteria,* through which air passes to the lung, and the oesophagus, through which food is transported to the stomach. The *trachea arteria* lies in front of the oesophagus, and upon it there is a certain cartilage known as epiglottis, which at times closes to prevent the entrance of food and drink, opening at other times to allow entrance and exit of air.

Between the *trachea arteria* and the oesophagus is a space known as the isthmus, between two walls, in which humors may collect and cause an abscess called angina; sometimes this is partly internal and partly external and is called quinsy; sometimes it is wholly external and it is then called *synanche.*

Next separate the *trachea arteria* from the oesophagus in order to expose the lung and heart. The heart is placed somewhat to the left side, and the lung on the right, and each is inclosed in its own capsule. In the capsule of the heart there may be an accumulation of matter, causing syncope; matter which gathers in the capsule of the lung causes peripneumonia.

Next you will observe a vein, called *vena concava,* which comes from the liver through the middle of the diaphragm and enters, from below, the inferior auricle of the heart. It then becomes an artery, and from

[1] The term *Lingua* evidently signifies the larynx rather than the tongue.

[2] The word *branchos* is defined as tumor of the throat several times in the Salernitan clinical literature. Dr. Singer has called my attention to the following passage in Aristotle's Historia Animalium (D'Arcy Thompson's translation): "the pig suffers from three diseases, one of which is called *branchos,* a disease attended with swelling about the wind-pipe and jaws. It may break out in any other part of the body," etc.

it arise all the other arteries which proceed to the members; in these the pulse occurs. By means of these vessels the heart is connected to the lung and draws air from the cavities of the lung. In these cavities fluid sometimes gathers and causes *sansugium;* at times it gathers outside and causes *anhelitus,* sometimes both inside and outside and causes *orthomia.* You can show the lung to be hollow by inflating it with a quill. Below these organs, and dividing them from the organs of nutrition, is a membrane called diaphragm, which is attached to the soft parts of the ribs, where the fluid gathers in pleurisy.

Now turn to the organs of nutrition and measure the length of the oesophagus as far as the seventh vertebra. The *os stomachi* begins above the diaphragm, but the stomach itself lies below. After the stomach comes that part of the intestine called *portanarium;* next is the duodenum, after the duodenum the jejunum, after the jejunum the *orbum,* after the orbum the *saccus,* after the saccus, the *longaon,* and in the region of the latter there are small intestines called *lateralia,* which are the seat of the iliac passion.

At the right side under the pouch of the stomach the liver is placed. In its substance there is a sac called the gall-bladder, and above the liver are two membranes, *zirbus* and *siphac,* which are folded together like a net. The one which appears thick and loaded with fat is called *zirbus,* but the one which is delicate is called *siphac.* These membranes reach as far as the spleen, and are traversed by veins through which black biliary humor (*melancholia*) is transmitted from the liver to the spleen.

The spleen is an oblong organ located in the left side. The regions under the spleen and liver are called hypochondria. Next remove all the intestines, whereupon the great artery will be visible in the middle of the spine; under it the great vein is found. The artery is formed from all the arteries of the head, which unite to make up one great artery, and this descends to the loins and sends off various arteries in a downward direction, both on the right and on the left. The great vein is made up of all the veins of the head, and reaches to the kidneys, where it divides; and there also is found the *vena chilis,* into which enter the capillary veins, too small to be seen, through which the urine with the four humors is transmitted to the kidneys. The kidneys are oblong hollow organs situated at the upper part of the loins.

Two passages called *uritides pori* are also found in this region, through which the urine oozes into the bladder, passing through a kind of membrane by which all the intestines are inclosed except the *longaon,* and which when broken allows the intestines to fall into the scrotum. Above this is a fatty structure called omentum. Above the omentum is the *siphac.*

It is next necessary to discuss the anatomy of the uterus. It must be recognized that nature has contrived this organ in women in order

that whatever superfluities are generated during the course of the month may be sent to this organ as if to form the bilge-water of the whole body; this is the nature of the menses which women have. This organ is also nature's field, which is cultivated that it may bear fruit; in which, when seed is sown, it remains as on good ground and through the cooperative action of natural warmth, and the mediation of vital spirits, it becomes implanted like a germinating seed, and sends out twigs through certain roots or mouths by which it is attached to the uterus, and through which nutriment is delivered to it and to the future foetus. Thus, later on, by the action of the bodily forces (as I have often told you, you may recall) the foetus-to-be is generated and augmented. The uterus is located above the intestine; above its neck is the bladder, and under it the *longaon.* Below is the vulva. Next cut the uterus through the middle of its os; you will find two testicles attached above it, by which the female seed is transmitted to the uterus and joins the male seed to form the foetus. The uterus has seven cells, and if the animal is pregnant, you will find the foetuses in these chambers. Over them you will find a kind of tunic, like a chemise, which is called *secundine.* This is broken when the foetus strives for exit. It is attached to the uterus and to the foetus by veins which run in it, and it carries nutriment to the uterus and to the foetus. Those openings by which the foetus is attached are called cotyledons. There is also a large channel, called umbilicus, which is broken (near the uterus when the foetus is delivered; midwives tie it) at a distance of four fingers from the foetus. When it is ligatured this causes phlegmons of the umbilicus.

Now let us examine the structure of the brain. You are to make an incision in the top of the head, and when the skin is removed you find certain layers which are called muscles, under which you discover a bone, called cranium. Under the cranium is a thin layer called dura mater; under this is the pia mater, then the brain. In the eyes there is a tunic called conjunctiva, which appears white. Next to it is the cornea, which is rather grayish; the layer under that is black and slight; it is called uvea. Next cut the eye through the center. The first humor which appears is called *albugineus,* the next is coagulated like a crystal and is called *crystallinus,* and the last is called vitreous. The nerve which comes from the interior to the eye, which is white and slender, is called *opticus,* and that which goes to the ears is called the auditory nerve.

THE SECOND SALERNITAN ANATOMICAL DEMONSTRATION

[Translated from the Latin text printed by Benedict, 1920]

In frame and fabric the animal body is composed of members various and diverse; for Nature, the First and Foreknowing Cause, greatly to be revered in all her works, constructed the animal body of many members differing in quantity and quality, in order that the animal kingdom might be the culmination of all created things. Therefore each kind of animal has bodily members appropriate to serve its spirit and nature. The lion, for example, since he is of bold and angry spirit, has a body perfected to these qualities and is provided with suitable weapons in the shape of claws upon his feet and very sharp teeth in his mouth. The hare, on the other hand, being the timidest of beasts, possesses members which by their lightness are adapted to swift retreat, and its forelegs are shorter than its hind legs, that it may easily run uphill. Because of these diversities in the endowment of nature and spirit, the Great Creator and Father of All Things formed organs adapted to various functions, such as the human hand, in which the fingers are several and distinct, in order to grasp objects both large and small. He suffused the liver with redness to promote the formation of blood, and with foreseeing discretion endowed the breasts and testicles with whiteness for the making of milk and sperm.

There are also three general operations, with three corresponding instrumental members, namely, animal, spiritual, and natural.[1] The animal members are created for sensation and voluntary motion in all animals; also in some animals for imagination and memory. The spiritual members are for protecting the channels of breath and natural heat. The natural members are nutritive and generative. The nutritive are for the reintegration of bodily loss and waste and for the alteration of materials permuted from evil to good. The generative organs are made for the specializing of general substance and for the individualizing of special substance. In each of these systems there is one principal organ with others protective, expurgative, and adjuvant or accessory.

[1] A modern translator can not preserve both the spirit and the letter of his original when dealing with the humoral physiology and the doctrine of vital spirits. A newer analytic physiology has driven the very terms out of the language, or given them altered connotations. Not only, for instance, has the word "animal" acquired a special meaning different from that of its Graeco-Latin significance, but the very idea of the *anima* is foreign to minds accustomed for reasons both religious and scientific to separate soul from mind, and both from life. The *virtutes spirituales* have ceased to be "spiritual" since Harvey and Mayow, having been analyzed into circulatory, respiratory, and thermic functions. However, to avoid circumlocutions, I have retained the terms animal, spiritual, and natural members and forces throughout these translations, leaving it to the reader to make the interpretation.

Among the animal organs the brain is principal, because the animal force is principally located in it, and from it arise the other structures such as the nerves; and it is provided with others protective, expurgative, and adjuvant or accessory. The protective are the pia mater, which, by enfolding the brain like a devoted mother, protects it from the harshness of the dura mater; the dura mater, which protects the brain and pia mater from the hardness of the cranium; and the cranium, which protects all of these from outward harm. The skin in turn protects the cranium from external injury. The expurgative and adjuvant organs are the ears, eyes, nostrils, and the tongue, with the palate. The ears drain the brain of biliary excess, the eyes of melancholic, the nostrils of sanguineous and phlegmatic; the palate drains away excess of phlegm. These organs are also adjuvant, for hearing is established by mediation of the ears, sight by the eyes, smell by certain caruncles which hang like udders in the ends of the nostrils; taste is mediated by the tongue. The nerves are accessory, because they receive animal spirits from the brain and transport them throughout the body to endue it with sensation and voluntary motion.

Among the spiritual members one is principal, namely, the heart, because the spiritual force is principally located in it and because other parts, such as arteries, arise therefrom; and it is provided with other structures, protective, expurgative or adjuvant, and accessory. The protective parts include that membrane surrounding the heart which is called *cassula cordis,* the diaphragm, and the ribs outside. The expurgative and adjuvant parts are the lung, the muscles of the chest, and some of the membranes, because by their motion air is drawn in to temper the natural heat, to restore the vital spirit, and to evacuate excess of vapors. The accessory parts are the arteries, which receive the vital spirits from the heart and convey them throughout the whole body to conserve the natural heat.

Among the nutritive members the liver is principal, because the nutritive force is principally seated in it, and because other parts, such as veins, arise therefrom; and it also is provided with organs protective, expurgative, and accessory. The protective organs include a certain membrane delicate as a spiderweb, and also a certain fatty structure, and much flesh on the outside. Expurgative are the lung and brain, from which excess phlegm is drained by the liver, black bile by the spleen, yellow bile by the gall-bladder, urine by the kidneys and urinary bladder. Several organs are accessory, for some prepare the food for alteration in the stomach, as, for instance, the teeth; others, such as the stomach and upper small intestines, digest and alter it preparatory to conversion into humors by the liver. Others, namely, the mesenteric veins, convey it to the liver; still others, the small intestines, attract to themselves the excess of moisture generated in the stomach. Finally,

other organs receive the four humors from the liver, together with the natural spirits, and transport them throughout the body; in this way they deliver nutriment to the whole organism.

Among the generative members the testicles are principal, because the generative force is principally located in them and because other parts arise therefrom; and they possess organs protective, expurgative, and accessory. In the first place, the testicles are protected by a covering called *osseum.*[1] The expurgative parts are the seminal ducts, which receive sperm from the testicles and deliver it to the penis. The accessory parts are those vessels which deliver sperm to the testicles, the uterus, and the breasts.

Knowledge of all these things is gained in many ways; from anatomy we learn their position and differences of structure and we get a simple and clear demonstration of their form. The word "anatomy" is derived from *ana,* or equal, and *tomos,* a division; hence an anatomy is an orderly dissection, and it is to be done as follows:

The pig is killed by cutting the throat; not as some do, by putting a knife into the heart, for thus a great quantity of blood is drawn to the vital members and they can be less easily examined. When the throat has been cut, the pig is suspended by the hind feet [2] with the head downward, so that all the blood may remain and not be shed; otherwise when the pig grows cold, there will be a constriction of the arteries and veins, and they can not well be distinguished. The ancients held various dissonant opinions on the subject of dissection; some said that anatomy should be studied from dead animals, others after due consideration declared that living animals were more useful for dissection, and the latter opinion prevailed on the authority of Galen, because the various passages are more easily visible when the living heat is still in them.

The pig is next placed on its back. When the lower jaw is partially separated from the upper, one sees the tongue, which is the organ of taste and speech; it is composed of soft flesh and is put together like a sponge, clothed by certain membranes which cover it entirely on the upper side, but which cover the lower surface only as far as the ligaments by which it is attached to the jaw. In some persons these ligaments are too far from the end of the tongue and the tongue is therefore too long and lax, so that it can not be moved upward for the production of semivowels nor downward for the production of consonants, and this is one cause of impediment of speech. But this varies in different men; in others the ligaments may be too near the end of the tongue, and the latter thus being unable to move in divers directions, speech is impossible.

[1] Scrotum.

[2] This sentence, which follows the reading of the Erfurt MS., can be made intelligible by omission of the word "hind" (posteriores) so that the pig is made to hang by all four feet in a horizontal position, with the head dependent.

In such cases the ligament should be cut, in order to allow motion of the tongue over the whole mouth and palate. At the sides of the ligaments and membranes are certain veins, as you have well seen, which conduct saliva to the tongue.[1] Next there are passages leading to the vital parts and to the brain, by which air drawn in through the nostrils passes in part to the brain and in part descends to the spiritual organs, as does also that air which is inspired through the mouth; thus occurs the collision and repercussion of spirits and vapors descending from the brain and arising from the spiritual organs, and this is the cause of sneezing.

By making an incision in the fauces there appear certain rather large, loose, and spongy glands, which some call *"faringes,"* but I do not give assent to this usage, because I have not found it written in any book, nor have I heard it from any teacher. The word *"faringes"* is properly applied to the projections of the gullet. There are also certain other masses which are smaller and firmer. These are all placed here for the purpose of gathering moisture from the brain and thus of preventing loss of motion by drying of the nerves and muscles. When abnormal humors gather here they cause *branchos* and scrofula.

Next let a small incision be made over the gullet. Certain muscles are seen by which voluntary motion is produced. When a similar incision is made laterally, other muscles appear between skin and flesh, and there are still others all the way to the joints of the leg-bones; in all these voluntary motion is produced. In swine they are all fleshy in the middle and cord-like and ligamentous at the ends. By means of a deeper incision the gullet is seen; this is the extremity of the passages of the lung, placed and formed here for a double purpose. Its first and chief function is to inhale air and to emit gross and vaporous superfluities; the second is to produce the voice, of which it is the chief instrument. It is formed of three cartilages. The first is convex inwardly and concave outwardly; in some men it can be palpated. The second cartilage is placed posteriorly near the oesophagus, wherefore some say (and this seems to be in agreement with the truth) that the second is relaxed at the beginning of the oesophagus when a man speaks, but the first covers the beginning of the trachea when he drinks; therefore if anyone while drinking suddenly attempts to begin speaking, the food finds an open passage through the trachea and passes downward; thus by irritating the vital spirit it sets up coughing. The third cartilage has a cavity continuous with the organs of vital spirits. It is to the projections of this gullet that the term *faringes* properly applies. To it the oesophagus is joined; in the beginning of this junction, which is called isthmus, there is a place as it were

[1] I take it this is not a description of the salivary ducts, but merely of blood-vessels supposed to carry blood bearing salivary ingredients, in the same way that the "milk-veins" are still supposed by farmers to subserve milk-formation in cows.

between two beginnings, that is, between the trachea and the oesophagus. When fluid gathers here it causes the first kind of quinsy; but if partly outside and partly inside it causes the second kind; if entirely outside it makes the third kind. If fluid gathers between the oesophagus and the spine—for the oesophagus is attached to the spine at the posterior aspect—it causes either a gathered swelling of the vertebra from within, if the gathering be in the middle, or torsion of the neck if it be lateral. Afterward look at the end of the third cartilage, where at its lower and inner side the oesophagus is joined to it; you will find there the beginnings of the recurrent nerves, which are also instruments of speech. Next to them is another and larger nerve, descending from above, which enters the mouth of the stomach, below the diaphragm. This is called *tornabilis.* When you have studied over these things, let a straight incision be made as far as the diaphragm. When the ribs are separated from the vertebræ, all the spiritual organs will be plainly discernible; first you will observe the *trachea arteria,* composed of many round cartilages in the form of rings, attached each to the other; on the inner side, to which the oesophagus is attached, the cartilages are bound to each other by membranous ligaments. The *trachea arteria* begins at the gullet; it descends the whole length of the neck as far as the lung, and divides at the beginning of the lung into two large branches which descend through the two great lobes of the lung. You may see clearly that the substance of the lung is distinct from the branches of the trachea arteria, as we have actually shown to many by dissection. Next observe that the lung is composed of delicate substance of slight density; it is cavernous, and formed of various lobes, so that the lung when expanded may receive air from the outside into these chambers and spaces, and may when contracted discharge the gross and vaporous superfluities; this you may see by blowing air in through the throat, for the lung is thus inflated to a large size. Fluid collecting above its lobes causes peripneumonia; if such matter were constantly collected within the lung it would end in phthisis, from ulceration of the lung tissues. Whenever fluid is abundant in the lung, it gathers and causes *sansugium,* which is difficulty of inspiration. When matter occurs about the lung and weighs upon it and impedes its dilation, it causes *anhelitus,* which is difficulty of respiration. When matter occupies the passages and inner spaces of the lung and resists its constriction, it causes *orthomia,* which is a combination of both difficulties caused by fluids inside and outside.

Next look between the two great wings of the lung, which are seen to comprise other lobes bulging on the posterior side; there you will plainly see a passage going to the heart, through which air is drawn from the lung to the heart and vaporous superfluities are transmitted from the heart to the lung. Clearly visible between these two organs there is a large branch of the vena cava ascending through the middle

of the diaphragm, which is plainly seen to bifurcate before reaching the heart. One of the branches passes upward; I have spoken fully about its division and distribution in my gloss on the *Aphorisms,* when discussing the passage "Posteriora capitis dolentia," etc. Another branch reaches the heart and there divides; one of its branches courses through the substance of the heart, chiefly superficially; the other, entering the right auricle from below, takes on another coat and becomes an artery. This passes out alongside the left [auricle?] and not through it; therefore, if you find "through the left" it is to be understood "alongside the left"; it is called *adorthi.* This again divides and the larger branch passes downward along the middle of the spine; we shall speak of this again at the end of the address. The other branch passes upward and divides into various branches, as may be read in the *Pantegni.* We have also referred to it when commenting upon Philaretus.

Next examine the heart in its position on the left side, bordered laterally by the lung, and covered everywhere by a kind of membrane which is called the capsule of the heart. An abscess can easily occur in the capsule, though in the heart itself never, or with difficulty. Oftentimes abnormal humors gather here in great abundance and cause syncope. The substance of the heart is composed of villous and nervous parts variously placed, and of firm flesh, being thus arranged because of the motions of dilatation and constriction, which are so diverse, extensive, and rapid that if the heart were of weak structure it might easily be damaged. Its form is that of a pine-cone, broad below and pointed above, and hollowed out into various chambers, both to permit of ready motility and to avoid angles which might do harm by retaining superfluous material.

Below all these organs is the diaphragm, which begins at the front where the chest wall is soft and reaches to the twelfth vertebra, where it is attached by cord-like ligaments from all sides; matter which gathers above it, in the membrane of the ribs, causes pleurisy.

Having demonstrated and gone over all this, let us proceed to the examination of the digestive organs. Some of these are above the diaphragm, namely, the oesophagus and opening of the stomach; the others are below it. That which is called *os ventris* in Latin is *stomachus* in Greek; for *stoma* is translated "mouth" and *cusis* "belly"; therefore *stomachus* is the mouth of the stomach, but in Arabic it is called *meri.* Although according to Constantine, *meri* includes under the one term both *os ventris* and oesophagus, actually it may be divided into these two structures. The part which is thicker and reaches about four fingers' breadths above the diaphragm is the *os stomachi;* the remainder, which is more slender and goes all the way to the throat, is the oesophagus; the *os stomachi* is nervous, in order that appetite may develop there as a result of frigidity.

Now let a deep longitudinal incision be made downward from the diaphragm, penetrating to a certain delicate membrane resembling a spider's web, which according to Constantine is called in Arabic *siphac* (not *asiphac,* as someone, not in a Hippocratic spirit, but from his own deep and searching knowledge, has recently borne witness, against whom I would have written something on this and other points were it not that it might be set down to pride). This membrane envelops all the nutritive organs and gives off the membrane which incloses the testicles.

Upon enlarging the incision, the *zirbus* appears, composed of two layers and resembling a net; it almost entirely covers the digestive organs. That part of it which covers the fundus of the stomach is called omentum from *operio operis,* because it covers the fundus of the stomach; but it is not the omentum—a certain person to the contrary—but a kind of fatty material, commonly called *axungia.* To tear it out is impossible or at least very difficult.

Next note the fundus of the stomach sloping toward the right, embraced by the liver with its five lobes; the stomach is fleshy, in order to promote the first digestion. Its lower orifice is called *porta* both by Constantine and by Isaac in his book *De urinis,* because it remains closed until in the necessity of nature food is to be passed out of the stomach, but opens when it begins to pass out.

Next observe the intestines, which Constantine in his *Pantegni* divides into six. Of these, the first is not the *portanarium* (because, as we have said, the *porta* is the inferior opening of the stomach), but the duodenum, which has a length of 12 digits. Next to it is the jejunum, so called because in the dead animal it is found to contain no fluid; from it, according to Isaac, the purer part of the juice formed in the stomach is drawn off through the mesenteric veins; but according to Constantine, this juice is drawn from the *subtile.* Yet these writers are not adverse to one another, but diverse; for Isaac means by jejunum that organ which begins at the duodenum and extends to the *orbus,* but Constantine applies the term jejunum only to the upper part of that which I have described, and distinguishes by the term *subtile* the lower part, which, as you have clearly seen, is more delicate than the upper; thus Constantine divides the structure into two parts. This portion of the intestine is the seat of strophic pain. The *intestinum subtile* ends in the *orbus,* which is also called *saccus.* It is called *orbus* because it is provided with but one opening, through which the contents pass both coming and going; it is also called *saccus* because it is made like a sack. An excess of bile going down to this intestine through the lower fork of the gall-bladder causes sickness. At the *orbus* begins another intestine, which is thick, called *yleon.* The iliac pain caused by retention of coarse refuse and by other causes often mentioned in the books is according to Constantine located here and not in "lateral intestines," which I have never discovered in

animals, nor have I found anything written about them except in the recent booklet. Lowest and last of all is the *longaon* or *extale* or *colum*. This is called *extale* or *longaon* because it extends along the spine from the lower extremity of the pudendal region. This intestine is the seat of colic pain.

Next examine the liver, which is situated in the right hypochondrium and is shaped like a Greek sigma. On the upper side, where with its five lobes it is joined to the diaphragm, it is convex. If matter gathers here it causes dyspnoea and cough, as Galen says, in the passages beginning "Per species disniae" and "Tussis quaeque fiunt, etc." On that side on which it is attached to the stomach, it is concave, and, as we have said, its five lobes surround the stomach. Although the number of lobes varies in different animals, there are five in the pig, as I have recently shown you, and certainly the same number occur in man. Upon one of the larger lobes is the gall-bladder, which gives the appearance of having but one duct. There are, however, two ducts, one above the other, so adherent and joined together that they seem but one; but while you have been watching I have separated them. The one which is uppermost appears larger. The larger one lies under the liver and is attached to it, and the lesser descends to the intestine, conveying excess bile to serve the function of the stomach. But the upper, which is larger, is continued to the fundus of the stomach, as I have clearly demonstrated to you; for while I had the liver separated thus from the stomach, somebody inquired how and where the branch in question continued to the stomach, and I made it known while you all looked on. One opening was cut in the fundus of the stomach; and in case someone who is anxious to criticize seems to find it missing, because it corrodes,[1] I say that the branch of the gall-duct which goes to the stomach is larger in the pig because of the smoothness of the stomach, for the stomach of the pig is smooth and not villous. Nature, therefore, in her providence, instituted the said branch, in order that food may quickly and without long retention by the stomach be brought to a great ebullition and alteration by means of mild bile reaching the stomach in large quantity through the larger branch. Moreover, the passage by which the liver transmits excess bile to the gall-bladder is continued to the larger branch, a fact you will easily understand by placing a quill inside the passage; for above it goes into the fundus of the stomach and then by somewhat transverse course it enters into the substance of the liver from below. And note that the stomach of the pig is not villous for two causes, one final and the other efficient. The efficient cause is moisture, for the pig is moister in its digestive organs than other animals and from this overflowing moisture comes smoothness. The final cause is the nature and substance of the pig; for in order that anything may be nourished, it is

[1] Literal translation of an obscure and possibly corrupt clause.

necessary that the nutrient material shall be similar to the substance which is dissolved from the body. Now, the substance and nature of the pig is somewhat cold and moist, and for this reason the pig's stomach ought not to be villous and long retentive of its foods, for these do not require a long time for ebullition.

When these things have been committed to memory observe the mesenteric veins in the concavity of the liver, in which is also the *lactea porta* or *vena ramosa* (which is called *lactea* because moisture generated in the stomach enters it as white as milk, *porta* because it is like a gate, *vena ramosa* because all the branches of the veins arise from it. You will find it about the middle of the concave side of the liver, where there is a certain whiteness of those membranes which unite the concave aspect of the liver to the fundus of the stomach. Below this in some recently killed animals I have seen those little narrow vessels, red and full of blood. If they are not visible easily and at once, divide and separate the membranes before mentioned and you will find many such vessels, as you have already seen.

Next you will find the hair-like veins in the convexity of the liver, where the vena cava is, in this way: Near the beginning of the vena cava break off a bit of the liver substance and rub it between your fingers and the veins will appear; they are small, round, and narrow like hairs. Somebody who wanted to criticize, last year after we had done a dissection, said these were nerves—a statement which we did not refute at the time. To confute his opinion we now exhibit, before you all, these vessels, red and full of blood, with their beginnings at the origin of the vena cava.

The spleen is oblong and is located in the left hypochondrium; it readily presents itself for observation. On its inner side it is attached lengthwise to the *zirbus;* on this side you will see, all the more easily because of the whiteness of the *zirbus,* three vessels full of black biliary blood. Since they are colored by these substances they are easily visible amid the whiteness. There is one about the middle of the upper end of the spleen through which part of the excess black bile is sent to the stomach to promote appetite; another about the middle of the lower end through which part is sent to the stomach; a third between the others, through which the liver drains off excess black bile. In some animals these black or red vessels full of black biliary blood do not course as described, and therefore are not so easily recognized. Carefully separate the *zirbus* from the substance of the spleen and the channels alone will remain because of their toughness; or put a quill in the middle of the spleen where it is joined to the *zirbus,* and insert it lengthwise, and you will find these channels.

When all this has been completed, let the organs which have been examined be removed from the pig, so that the rest may be better seen;

and first observe the kidneys, situated on either side of the spine, fleshy and round. They are venous within, and contain corpuscles after the fashion of hairs; and they are hollow, which is the cause of stone. From them descend two vessels called *emunctoria* by physicians, one of which descends to each side of the neck of the bladder. Also, there are fleshy masses on each side of the spine, called *lumbi.*

In males [1] the bladder is situated above the rectum (that intestine which, as I have said, is called *colum*) and therefore these organs are much bound together and become involved in the same lesions (see Hippocrates, the *Aphorisms:* "Ex strangiria, etc." and elsewhere "In ano flegmonem patientem," etc.) Stone occurs in the fundus of the bladder, and if it reaches the neck it interferes with the passage of urine and causes strangury and *scunia.* Also, there is in the neck of the bladder a certain constricting muscle which does not permit the urine to pass without volition. Around the fundus are nerves and muscles, which you have clearly seen; when animal spirits flow down to these they are compressed and contracted, so that urine passes out through the neck of the bladder. How the neck of the bladder is continued into the penis you may see by putting a long quill through the neck.

The large artery which descends from the heart, about which I promised I would speak, descends along the middle of the spine as far as the kidneys and there bifurcates. One branch proceeds to each kidney; and from other branches which pass downward two branches are separated, one going to each testicle to give it vital spirits. The remainder of the descending branches are distributed in various ways to the thighs and other members.

The venous branches from each side of the spine descend to the inferior regions and give off two branches, one of which goes to each testis to convey blood. The remaining branches are distributed in diverse fashion throughout the lower members; some of them descend to the pudendal ring and there undergo multiple division. These give rise to haemorrhoids, as we have made known to you.

The testicles, which are the instruments of the sperm, are formed of glandular, white, soft, and spongy flesh, in order that sperm may be generated in them. Each is covered by a membrane, which is derived from the *siphac.* The substance of the sperm before it comes to the testicle is received in a certain follicle, in which it is altered and whitened, and this membrane is below the kidneys and above the testicles; in some animals there is found in the said membrane a great quantity of that moisture which is the material of the sperm; in other animals little is found, and in others none; and as we have shown you, there are two passages, one on each side of the membrane, through which this material

[1] I take the word *maribus* from the corresponding passage in Constantine, instead of the unintelligible *natibus* of the MS.

descends to the testicles. Proceeding from the inferior part of the testicles are two vessels called *seminalia,* through which the sperm passes from the testicles to the penis, and these vessels are long, white, and hard like muscular flesh; they are long, so that the testicular excretion may better undergo coction as it passes along, and broad, that the sperm may pass quickly from these vessels into the penis and from the penis into the female pudenda. In your presence I have incised one of these ducts and have shown you the sperm.

The penis is fleshy, nervous, round, and hollow, beginning at the two *ossa pectines;* and is formed of two cords placed side by side transversely, which is necessary for double cause. First, that it may eject the sperm into the vulva; for this reason it is made nervous, in order that by virtue of its great sensitiveness there may be intense pleasure even in so unseemly an act as emission of the sperm. It is hollow, in order that in the presence of ardent desire it may be extended and erected with the greatest possible rigidity by means of much spirit in its large cavity and in the muscles placed at its sides; and thus it is not readily deflected, but may be inserted directly into the vulva. The second necessary cause is that it may expel the urine passing through it from the neck of the bladder without interruption and without harm, as we demonstrated very clearly in the dissection by means of a quill inserted through the neck of the bladder.

The uterus is a hollow and nervous organ placed lengthwise, beginning at the umbilicus and descending into the region of the female genitals. It is placed above the *intestinum rectum,* which as we have said is called *longaon,* and the bladder in turn is above the uterus; so that when enlarged and distended by the bulk of the foetus the intestine and the bladder form as it were cushions and cover it on both sides. It has two orifices, one external, which is properly called *collum matricis,* in which coitus is completed; the other internal, which is properly called *os matricis,* and this closes, according to Hippocrates, after the seventh hour of conception, and will not thereafter admit the point of a needle. The os itself is nervous and somewhat sensitive, in order that much delectation may be caused in intercourse by contact of this organ with the male member, and it is moderately firm, in order that it may easily be distended for the entrance of the sperm and closed when the sperm is received; for if it were not so—if it were over-hard or over-soft—it would be inextensible through hardness or for softness could not be shut. The *matrix* is villous inside, that it may better retain the sperm and the foetus when conceived. For it is constructed for this special purpose, namely, generation of the foetus from sperm conceived within it. The superfluities formed in it are discharged by the menses. There are two large cavities in the uterus, one right and the other left, but both of these unite in one, which is properly called *collum matricis;* and there are certain

pits in them from which the menstrual flow originates and in which by conception of sperm generation occurs as follows:

Acting upon the mass composed of male and female sperm, the natural force and heat cause solidification in the liquid and more subtle parts as well as in the superabundant and more consumable grosser elements, and alters them into a kind of membrane, just as a crust forms on dough when a hot iron is brought near it. Then when the rest of the mass is coagulated throughout by similar action of force and heat and becomes transmuted into the essence of organs, its swelling bursts the middle of the crust. Veins and arteries emerge and are united with the veins and arteries of the uterus to form the *secundines,* or membranes of the foetus; and through these veins the four humors, the natural spirit, and the vital spirit are borne for nourishment and vivification of the foetus. The sources of the veins and arteries of the uterus, to which the veins and arteries of the foetus are joined, are called cotyledons. By these veins and arteries, as if by ligaments, the foetus is suspended and is retained in the uterus, but they are broken when the foetus departs at birth, and after the waters have been discharged the midwife ties them with a thread at a distance of three or four fingers' breadths from the umbilicus. It often happens that due to pain from the ligature humors are drawn thither and cause suppuration of the umbilicus.

After considering all this, note the two testicles situated at the summit of the *collum matricis,* one right and the other left. You will find them by a long straight incision above the *collum matricis.* The testicles are smaller than in men, round, superficially somewhat flattened, glandular, and harder than in men. To each of them comes a single vein from the kidneys, and they lie under the trumpet-like extremities of the uterus. From each testicle there goes a stem-like cord, through which the testicle ejects sperm into the spermatic vessel. Observe, moreover, that the female organ, which as we have said is called *collum matricis,* is different in different women according to varying times, ages, and natures; for in pregnant women it is greater than in the non-pregnant because of the enlargement caused by conception; it is never so large [1] in those who have never been pregnant as in those who have borne children; and moreover it increases in size during the course of pregnancy. In girls and elderly women this organ is smaller than in adults, and in ardent women it is larger than in those who are not passionate.

Concerning the anatomy of the head, we may say that it is of rounded form, but tapering before and behind. It is round in order that it may not be subject to injury; for if there were angles tending to retain superfluities, they would be a source of harm. It is tapering in front because of the chamber of imagination and the sensory nerves, which

[1] The MSS. have "small" (minores), which is obviously an error; the corresponding passage in Constantine reads *majores.*

proceed to the organs of sensation; and it tapers behind because of the chamber of memory and the motor nerves, which run to the organ of locomotion, and also because the spinal medulla makes its exit at the rear. Let the cranium be centrally incised, above and below, down to the dura mater; it is found to be rough on its inner surface, hollowed out in one part, jagged in the other, and composed of many bones interlocked. The purposes of this arrangement are several; it makes the head an efficient outlet of the great ascending vapor which is resolved from the triple digestion; it permits freer entrance and exit of the veins and arteries of the brain; finally it causes firmer adhesion of the cerebral membranes and thus if perchance any one part of the skull is fractured the whole need not collapse. Immediately under the cranium there is a membrane called dura mater, which protects the brain and pia mater from the hardness of the cranium; when this is incised there is found another membrane like a network of veins; this is called pia mater and protects the brain from the harshness of the dura mater. Under the pia mater is the brain, which is white, soft, and chambered. It is made white and soft in order that it may fully respond to the diverse qualities of sensations. From the forepeak of the brain proceed all the sensory nerves, among which is a large one called *opticus* or *ocularis,* from *obtalmo* (that is to say, eye), which descends as far as the crystalline humor, which is in the middle of the eye.

The eye is composed of four humors and seven tunics, which are recognizable as follows: One tunic, which begins at the center of the eye and lines the whole inner surface, is the conjunctiva. The outermost superficial layer is the cornea; a bit of it cut off appears bright and clear like very translucent horn. When this is cut away still more, a very black layer is found beneath it, and this is called uvea; under it is a very delicate membrane called *tela aranea* or pupil. There are three others on the cranial side; the first is retina, the next *secundine,* the third sclerotic.

After you have seen these things, cautiously make a deep incision in the center of the eye and compress it slightly at the sides. The first humor which emerges, resembling white of egg, is called *albugineus.* After that, a clear, translucent, and rather firm humor escapes; this is called *crystallinus.* The third, which escapes from about the crystalline humor, but which is softer than the crystalline, is called vitreous. The before-mentioned optic nerve, which descends from the brain to the eyes, passes through the center of the eye as far as the crystalline humor; through it comes the visible spirit, and as it emerges through the uveal tunic and the cornea it is mingled with clear air and transports its rays to the body, and thus sight is brought about, as we have said in our commentary on Johannitius.

ANATOMIA MAGISTRI NICOLAI PHYSICI

[Translated from the Latin text printed by Redeker, 1917]

As Galen advises, if anyone desires to know the arrangement of the internal and external members of the human body, he must undertake the practice of anatomy. Therefore let us consider what anatomy is and why it is so called, upon what animals it was practiced by the ancients and upon which by the modern, and what are their species and divisions. As we have it from Galen, anatomy is the correct division of the animal members. The word is derived from *ana,* meaning straight, and *thomos,* meaning division; whence *anatomia,* that is to say, correct division of the members. Among the ancients dissection was practiced upon both the living and the dead. The anatomists went to the authorities and claimed prisoners condemned to death; they tied their hands and feet, and made incisions first in the animal[1] or major principal members, in order to understand fully the arrangement of the pia mater and dura mater, and how the nerves arise therefrom. Next they made incisions in the spiritual members, in order to learn how the heart is arranged and how the nerves, veins, and arteries are interwoven. Afterward they examined the nutritive organs and finally the genitalia or subordinate principal members. This was the method practiced upon living bodies. A different method was used upon the dead; they took a crucified corpse and fastened it with rope to a stake in a running stream, with hands and feet tied, so that after a time the skin, flesh, fat, and other superfluous parts were removed by the action of the water and the arrangement of the internal members could clearly be observed. Thus Galen, a remarkable physician of those times, composed two books of anatomy of the dead and one of the living; but such treatment of the human body came to be considered inhuman, especially by Catholics, and the practice of dissection was transferred to animals. Now, some kinds of animals are much like man, especially in outward aspect, for instance, monkeys and bears, while others, such as the pig, are similar to man internally; and therefore the anatomists chose the latter kind, and in particular the female pig, which shows the greatest likeness to the human structure in all internal organs, including the uterus.

Next let us discuss the species and divisions of anatomy; and because its classification depends upon members, let us see first what a member is. A member is defined thus: It is a part of an animal which is firm and solid, composed of similars or dissimilars, and assigned to some special function. "Part of an animal" is specified in order to exclude branches, which are not parts of animals but of trees, and also to exclude parts of wood and stone. Note also that the term "part of an animal" may

[1] See note, p. 54.

denote either *act* or *aptitude*. If it denotes act, it is accidental, because according to this it is a constituent part of the animal; if it denotes aptitude it is substantial, because according to this it is a constitutive part of the animal; for instance, the hand of the embryo before the infusion of life is a constitutive but not a constituent part of the animal. The term "firm" is specified to exclude spirit, which is not a firm part. "Solid" is specified to exclude humors, which are not solid parts. "Composed of similars or dissimilars" refers to consimilar and official members. The phrase "assigned to a special function" is specified to distinguish the idea "part of an animal" in this sense from mere fractional parts such as a third or a quarter of an animal.

The classification of members is three-fold. First, they are either consimilar or official. A consimilar member is one which is of the same nature throughout, that is to say, of the same species or complexion. The latter phrase is specified to allow for the case of the arteries, which consist of two layers, one of which is not of the same species, although of the same complexion, because all arteries are of one complexion, for every part of an artery is arterial. The same applies to other members. The consimilar members are twelve in number, namely, skin, flesh (*caro*), fat, muscle (*musculus*), *lacerta*,[1] bones, nerves, veins, arteries, ligaments, tendons, and medulla.[2]

An official member is one which consists of various consimilars, such as the hand, which consists of skin, flesh, veins, nerves, and the like. Again, some members are principal, some on the other hand are derived from the principal members; some have innate powers, others have both innate and inflowing powers. The principal members are four, brain, heart, liver, and testes. The first three, that is to say, brain, heart, and liver, are called principals (*principalia*), because they maintain the individual in existence. No animal is to be found which has not these three members, unless it be the acephalic animal which is said to have no head and consequently lacks a brain. The testes are called principal members because they maintain the species in existence by material transmission. If there were not generative power in the testes, the human species would perish, and the same holds good for other species.

The members derived from the principals are the nerves, veins, arteries, and seminal ducts. All the nerves arise directly or indirectly from the brain, all the arteries from the heart, all the veins from the liver. The seminal ducts, both superior and inferior, arise from the testes; the superior are called *didymi,* or dubious, because it is doubtful whether they are derived from the kidneys or the testicles. The inferior are

[1] The author appears to have listed muscular tissue thrice, under *caro, musculus,* and *lacerta.*

[2] I omit from the translation at this point five lines on the eye which are obviously interpolated.

the emunctory vessels, which receive the sperm and carry it through the penis into the mint of conception. The members having innate virtues are consimilar members, which have four natural forces, namely, appetitive, digestive, retentive, and expulsive. The appetitive is that which digests, the expulsive that which expels. The members having both innate and inflowing powers are the official members, which have the innate or natural powers of the consimilars of which they are composed. They are said to possess also inflowing powers, not meaning that anything flows from place to place, but because there are forces in them performing their function, such as the animal force and the spiritual force. For example, the animal spirits are carried by the nerves to the hand to produce sensation and voluntary motion, the vital force is carried by the arteries to confer vitality, and so forth.

The third classification of the members is as follows: Some members are animal, others spiritual, others nutritive, others generative. The animal members are the brain, pia mater, dura mater, and the like. They are situated above the epiglottis. The spiritual members, namely, the heart, the lung, and so forth, are situated between the epiglottis and the diaphragm. The nutritive members, namely, the liver, spleen, stomach, and the like, are between the diaphragm and the kidneys. The genital members, namely, the testes and seminal vessels, are below the kidneys.

The brain, being the most important of the animal members, is surrounded by other structures, either protective, expurgative, or subservient. It has as protective structures the pia mater, dura mater, cranium, and overlying skin. The pia mater immediately surrounds the brain with its arterial net, and shields it from the dura mater, which is cartillaginous and hard as cardboard. This membrane is called pia mater because it surrounds the brain like a devoted mother embracing her child. The dura mater guards the brain from the hardness of the cranium. The name *miringae* is also applied to these two membranes. The skull and overlying skin protect the brain from external injury. As expurgative members the brain has the eyes, ears, nostrils, and palate. Through the eyes it is drained of black-biliary humors as rheumy discharges; through the ears its biliary humors are discharged as yellow fluid; and through the nostrils and palate the brain is purged of phlegmatic humors as *rascationes* (?). The brain has also subservient members, namely, the nerves; for the animal spirits are carried by the nerves to all the members, endowing them with sensation, motion, and what not.

The heart, being the most important of the spiritual members, has certain members which are protective, others expurgative, and others subservient. As defensive members it has a kind of capsule which surrounds it and protects it against the hardness of the ribs; and in turn it has the ribs, which protect it against external injuries. For expurgative members it has the canals of the lung and the trachea. The

pulmonary canals drain it of superfluities engendered by frequent ebullition of the blood, carrying away the foam to the trachea, by which in turn it is carried to the mouth and thus ejected with the sputum. As subservient members the heart has the arteries, which take the vital spirits and blood which it generates and carry them to the members to give them heat and life.

The liver, which is the most important of the organs of nutrition, is provided with certain members which are protective, others expurgative, others subservient. As protective members it has the *zirbus* and the *siphac,* which envelop it and protect it from the hardness of the ribs; in turn the ribs protect it against external injuries. It has several organs which drain off the various superfluities formed in it, namely, the gall-bladder draining it of excess bile; the spleen draining it of excess black bile; the brain, heart, and stomach draining off excess of phlegm; and the capillary veins and ureters, which carry off the urine into the bladder. As subservient members the liver has the veins, which provide it with nutrient blood.

The testes also, as the most important of the generative organs, are provided with certain members which are protective, others expurgative, others subservient. As protective members they have the scrotum, the little pouch in which they hang, which protects them against the pressure of the thighs, and in turn the thighs protect them from external injury. As expurgative members they have the emunctory vessels, which carry the sperm from the testes by the way of the penis into the mint of conception. As subservient members they have the *didymi,* which carry to the testes the raw materials from which they generate the sperm.

The brain, which is the most important among the animal members, is, according to some, of hot complexion; according to others, cold; according to others, moist; in substance, subtle, thin, and soft; in color, white; in constitution, hollow and spongy; in form, oblong with a degree of rotundity. It is covered by the scalp and the skull, and is inclosed in two membranes. It has much of spirit and much of marrow. It is mobile with a twofold mobility and divided into three cells. According to Aristotle, it is hot of complexion, as Isaac testifies in his work, *De dietis universalibus,* but according to Hippocrates it is cold (at least as he seems to hint in the *Prognostics,* where he says that cold harms the brain, spinal medulla, nerves, arteries, and consimilar members in general). All agree that the brain is of moist complexion. In substance it is subtle because of its subtle operations; it is thin and soft in order that it may easily receive impressions and easily give up what it has received. It is white in color, so that it may freely receive impressions of different colors, since white is the most sensitive of colors. In constitution it is hollow and spongy, that it may hold the wastes derived from condensation of vapors rising to the brain, for if they were not detained

there they would impede the circulation of spirits destined to carry out the operations of the mind. In form the brain is oblong with a degree of rotundity; round that it may be as mobile as possible in performing its functions, and so that it will not give room for much waste material; oblong, that its motion may be slow and not impetuous. Its two membranes are to protect it from the hardness of the skull. It is covered by the skull and scalp to protect it from external injury, as mentioned above. It has much of spirits and much marrow; much spirits, to provide sensation and motion in the members and to carry on the various activities of the mind; much marrow, to permit the free perception of diverse forms and shapes. It is mobile with a twofold motion, namely, systole and diastole, so that these motions may create an upward flow of heat, which cleanses the substance of the brain and consumes wastes retained in the cavities. It is divided into three cells, the cellula phantastica in the anterior part of the head, the cellula logistica in the middle, the cellula memorialis in the posterior part. In the cellula phantastica imagination is said to have its seat, reason in the cellula logistica, memory in the cellula memorialis. The first cell is hot and dry, having much spirit and a little marrow; the second is hot and moist, having much spirits and much marrow; the third is cold and dry, having little spirits and much marrow. The cellula phantastica is hot and dry, having much spirits, for the following reason: Just as among the natural forces we find the attraction of nutriment by the appetitive force aided by heat and dryness, so also among the animal forces there is an attraction brought about by similar qualities, namely, heat and dryness. This cell has much of spirits, to provide for the carrying on of its functions, and it has little marrow, in order not to impede the flow of spirits in apprehending the nature of things. The cellula logistica is hot and moist for the following reason: Just as among the natural forces there is digestion of what has been received, and separation of the purities from impurities of the diet, by the action of heat and moisture, so also among the functions of the mind there is a property of discrimination brought about by heat and moisture, by which things received into the cellula phantastica are distinguished, for instance, the true from the false, the honest from the dishonest, merriment from sobriety, and other contrasting things. It has much of spirits, in order that there may be full discrimination of ideas received; it has much marrow, in order that the spirits depleted by these subtle operations may be replenished. The cellula memorialis is cold and dry, for the following reason: Just as among the natural functions, there is first an attraction of nutriment by heat and dryness, and digestion by heat and moisture, and then there must be retention by means of cold and dryness; so likewise among the functions of the mind, besides the attraction of ideas to the cellula phantastica by heat and dryness, and the separation of the true from the false, and

so forth, in the cellula logistica, by heat and moisture, there must be also retention, and this is carried out in the cellula memorialis by the action of cold and dryness. For this reason that cell is called "treasure house of the memory." It has much marrow, that it may be easily stamped with the impressions of diverse ideas, but not much spirits, which might flow about and remove the impressions of ideas. On account of the three divisions of the brain the ancient philosophers called it the temple of the spirit, for the ancients had three chambers in their temples, first the vestibulum, then the consistorium, finally the apotheca. In the first the declarations were made in law-cases; in the second the statements were sifted; in the third final sentence was laid down. The ancients said that the same processes occur in the temple of the spirit, that is, the brain. First we gather ideas into the cellula phantastica, in the second cell we think them over, in the third we lay down our thoughts; that is, we commit to memory.

Next come the nerves. Of these, some are sensory, others motor. The sensory nerves are those which serve sensation chiefly, serving motion only secondarily. The motor nerves act conversely. According to some authorities, all the sensory nerves originate from the cellula phantastica, the motor from the cellula memorialis. There are also five kinds of sensory nerves, which are classified according to the operations of the five senses, namely, sight, hearing, smell, taste, and touch. Two nerves arise from the cellula phantastica and cross in the middle of the forehead, one of them passing to the pupil of the right eye, the other to the left. Through these nerves visual spirits are conveyed to the pupils. How vision is produced will be described elsewhere. The nerve in question is called the optic nerve, from the Greek word "optos" which signifies *visus* in Latin. Two other nerves arise from the cellula phantastica, one of which goes to the right ear, the other to the left; through these auditory spirits are conveyed to the petrosal region. These nerves are called ophthalmici or postici,[1] because they arise in the posterior part of the cellula phantastica. Another nerve arising from the cellula phantastica passes to the caruncles in the nose, which are spongy and formed like paps. Through these nerves olfactory spirits are borne to the caruncles. A gustatory nerve also arises from the same cell . . .[2] which pass through the neck, to the right and left arms. The one which goes to the right arm is prolonged to the hand and divides to enter each of the five digits. A branch of this nerve, beginning in the right arm, goes on to the right foot and enters the five digits, more or less, which are upon the foot. You may consider that the same is true of the nerves of the left side.

[1] As Redeker points out, a similar confusion of terms exists in several of the Ricardus manuscripts and in Schwarz's variant of "Copho."

[2] There seems to be an omission here.

Having discussed the sensory nerves, we now take up the motor nerves. The motor nerves are those which primarily serve the motor function, only secondarily assisting in sensation, as, for instance, that of touch. All the motor nerves originate from the cellula memoralis, just as the sensory nerves arise from the cellula phantastica, although some say that three species of sensory nerves, namely, sensory, gustatory, and olfactory, arise from the cellula phantastica, and two other species, auditory and tactile, arise from the posterior part. In the same way they say that some motor nerves, namely, those of the eyebrows and eyelids, arise from the anterior part, while others, namely, the motor nerves of the ears, lips, and other regions, arise from the posterior part. This seems, indeed, to be the meaning of Galen in the *Tegni,* where he says: "Ipsa quoque pars anterior pluribus autem operativis, quem posterior pars pluribus operativis, paucioribus autem sensibilibus." Two other nerves arise from the posterior part, one of which goes to the right jaw, the other to the left. The one which goes to the right traverses the upper jaw and enters the lower and the one which goes to the left does the same. It should be remarked that in every kind of animal that jaw in which the motor nerve ends is the larger, except in the crocodile, in which the contrary condition occurs.

The posterior part of the cranium is shaped like a Greek *lambda,* and is called commissura from *com* and *mitto,* because the cranium and spine are put together or joined there.

The spine consists of 18 vertebræ, of which there are 6 cervical and 12 dorsal. The vertebræ are all perforated to allow for descent of the medulla or cord. The cord arises from the brain and is protected by two membranes, namely, pia mater and dura mater, and is formed like a horse's tail or like a willow switch. From the commissure of the cranium certain nerves originate which extend to the root of the tongue and are called motor nerves of the tongue, because they move the tongue in mastication and also in the production of speech, although the voice is not actually generated there, but these nerves by their motion modify the voice. Likewise, certain other nerves arise from the same commissure and pass through the whole length of the neck to the heart and surround the sides of the heart; by means of these, animal spirits are carried to the heart to produce the emotions, such as anger, joy, sadness, and the like, for all the operations of the mind and soul originate in the brain and terminate in the heart. Still other nerves begin in the same commissure and pass through the whole length of the neck to the upper orifice of the stomach, where they terminate; by these, animal spirits are borne to produce appetite, for appetite is composed of two forces, namely, animal force and simple natural or appetitive force, which flourishes by the action of warmth and dryness. Warmth dissolves and resolves superfluities and dryness consumes them. When the stomach

perceives its own emptiness, its upper parts touch each other, and thus arises the desire to eat, as a result of tactile sense and of appetite; or, to put it in other words, by the action of animal force and of appetitive force. Other nerves arise from the sixth dorsal vertebra, counting from the upper end, that is, the neck, and these go to the lung and pass through the middle of the pulmonary region; thereafter they turn back and reach the tongue, whence they are called *nervi reversivi.* In some people they terminate at the proper distance, in some they fall short, in others they go too far. Those in whom they end at the proper distance are able to form all sounds of the voice; those in whom the nerves are too short can not produce the letter *r* and are said to be tongue-tied; those in whom the nerves are too long can not form the letter *s* and are said to lisp.

Also, other nerves arise from the same vertebra and go to the sternum, where they become superficial and connect the sternum with the spine, in order to bring about inspiration and respiration. Still other nerves arising from the same vertebra pass by way of the middle ribs to the inner side of the sternum, where they join the flesh to form a muscle by which the air is gently expelled, as in laughing; but other nerves arising from the same vertebra go as far as the trachea or the lower part of the throat, and join with flesh to form a muscle by which air is forcibly expelled, as in coughing. From the same vertebra arise nerves which pass to the upper part of the throat and join with flesh to form a muscle by which vocal sounds are produced, not definite words, but merely sounds. To form actual words, nine instruments are required, which are called by the authors "the nine muses." These are the lung, pulmonary canals, trachea, epiglottis, tongue, palate, the two upper and two lower incisor teeth, and the two lips. From the junction of the dorsal and cervical spine two nerves originate, one of which goes into the right arm, the other into the left; they descend to the hands and there divide into five twigs, one for each finger. Through these branches animal spirits are borne, primarily to produce motion, but secondarily to cause sensation.

At this point it should be noted for the sake of clearness that there are in the human body two humeri, two homoplatæ, two spatulæ, two metafrenones, two sides, two thoraces, and the sternum. The humerus is the highest part (of the arm) next to the dorsal spine. The homoplata is a broad bone in the shoulder. It is called homoplata from *homos,* meaning bone, and *platon,* which means broad; from the same word we get also *platea,* a broad way, and *plato,* having a broad aspect. The spatula consists of the shoulder and the homoplata. The metafrenones are certain bones in the back which reach as far laterally as the backbone and as far upward as the thoraces. One is in the right side, the other in the left. The thoraces are those anterior parts which contain the nipples; they extend to the subcinctorium. The right side is opposite to

the left side; the sternum is opposite to the backbone; the right thorax is opposite to the right metafrenon (and likewise on the left). The word metafrenon comes from *meta,* next to, and *frenum,* bit; it signifies therefore "next to the bit," or next to the diaphragm. Just as a bit separates the upper part of a horse's mouth from the lower, so the diaphragm divides the spiritual from the nutritive members. Notice that the thoraces are sometimes larger than the metafrenones and sometimes smaller; the cause of this is given by Galen in the *Tegni.*

Several nerves arise from the cervical cord and leave the spine to enter the various regions mentioned above and the internal organs, namely, the stomach, liver, and the like, bearing animal spirits primarily to produce motion in them, and secondarily to produce tactile sensation. Two nerves arise at the end of the dorsal spine, one of which passes to the right leg and the other to the left; they descend the whole length of the thighs and lower legs into the feet and there divide according to the number of the toes. Through these nerves animal spirits are borne to produce motion and sensation. Other nerves arise from the spinal cord and pass through the spine to reach the chest and the perineum. The union of these nerves forms the penis in the male sex, and therefore this organ is extremely sensitive and has even been called by some *cauda nervorum.* In the female sex a similar concourse of nerves forms the foramen, or gateway, or vagina. Another nerve arising from the spinal cord joins the vertebrum with the *scia* and this is called ligamentum, or *tenuntos,* or *zementis* (different people give it different names); sometimes this nerve becomes elongated and then the vertebrum is loosened from the scia and sometimes the nerve breaks suddenly and gives rise to sciatic pain. The *scia* is a certain hollow bone, and the vertebrum a round bone seated in the hollow of the former, called vertebrum from *verto,* to turn, because when a person moves it usually turns.

It is usual at this point to classify the tissues according to their hardness. Fat is the softest tissue, flesh is next, then skin, then the sensory nerves, then the motor nerves; after them comes that ligament or tenuntos which we have just mentioned, then cartilage, and finally bone.

Having described the animal members, let us proceed to the spiritual members, first discussing the heart, which is the most important among them. The heart is hot and dry in complexion, solid and hard in substance, dense in constitution, conical in form; with a pointed apex below and a broad base above; hollow inside; having two auricles, right and left; motile with a twofold motion; situated in the middle of the body, and surrounded by a capsule. It is hot in complexion, to increase its motion, for hot things move swiftly, cold things slowly. It is dry because by means of its dryness it is able to consume waste products. It is hard and solid in substance and dense in constitution for one single reason, namely, that it may the better resist the continual and frequent

ebullition of the blood. It is shaped like a pine-cone, pointed below and broad above, for the following reason: We know that fire tends to rise in the shape of a cone, because it is hot and dry, and the same effect must take place in the heart and every fiery organ. It must be explained, however, that the apex of the heart is turned downward and therefore the broad part is above, because the heart receives its nutriment from the brain, which is (so to speak) the root of all the organs. Just as a tree receives nourishment from the root below it, so do the heart and other organs receive nutriment from the parts above. For this reason man has not inaptly been compared to a tree upside down. Inside, the heart is hollow, to provide for ebullition of the blood and generation of the vital spirits. It is inclosed in a capsule, for the sake of protection from the hardness of the ribs. It is motile with a twofold motion, namely, diastole and systole; note that diastole, elevatio, and thesis all have the same meaning, while systole is identical with depressio and artheos or arsis. There is a twofold cause of diastole of the heart, that is to say, an efficient and a final cause. The efficient cause is the inspiration and expiration of vital spirits and air; the final cause is the need of resting the heart and of renewing the vital spirits. There is also a twofold cause of systole. The efficient cause is the heart's heaviness or weight, for everything heavy tends toward its center; the final cause is the need of ejecting wastes produced by ebullition. The heart is placed in the center of the body for the same reason for which the sun is placed in the center of the world, namely, that its heat may be evenly distributed to all the lands; and accordingly the heart is so placed that its heat may be evenly distributed to all members. The heart has two auricles, right and left, so that the vena cava entering the right and leaving the left auricle may become arterial, for the vena cava is made up of delicate venules which come from the vena ramosa.

The vena cava is so called either because it gathers much nutriment or because it passes near several hollow organs such as the heart, lung, pulmonary canals, and trachea. This vein, as it egresses from the dome of the liver, divides into two branches, one of which goes upward and the other downward. The one which courses upward passes through the middle of the diaphragm and enters the right auricle of the heart; and then leaving the heart via the left auricle it takes on a new layer derived from the substance of the heart and is called the aorta, because all arteries arise from it. Note that the difference between a vein and an artery is that the vein has one coat, the artery two. As the aorta leaves the left auricle it divides into two branches, one of which goes upward, the other downward. The one which goes downward descends to the stomach, liver, the dome of the liver, the kidneys, and to the legs, where it finally reaches the feet and divides into small branches to each digit. Through this artery vital spirits and arterial blood are borne to

produce heat and life in the lower members. The branch which goes upward divides into one smaller and two larger branches. The smaller branch passes directly through the left arm to the hand, where it is subdivided into branches for the fingers in order to carry heat and vital spirits. On account of the shorter distance and more direct course the pulse is felt more clearly in the left than in the right hand. One of the other two branches passes by way of the lung and the right arm to carry vital spirits into the hand; because of the greater distance and less direct course the pulse is not so clearly felt in the right arm. The third branch enters into the substance of the lung, where it subdivides into numerous branches, of which the pulmonary canals are formed, and through these branches occur the inspiration and expiration of air and the discharge of wastes generated in the heart. The arteries and pulmonary canals unite as they leave the lung, forming the trachea, through which the wastes withdrawn from the heart by the canals are freely discharged. There are also other arteries which pass upward in the neck alongside the trachea and through the temples to the brain. Some say that they enter the substance of the brain, others that they form an arterial net which closely surrounds the brain and supplies the pia mater and dura mater.

The lung is a member firm and moist in complexion, soft and delicate in substance, hollow and spongy in constitution, pennate in form, and motile with a twofold motion. It is firm and moist, in order to withstand the warmth of the heart and so that no lesion may be caused by the heat of its own motion. It is soft and delicate in substance, so that it may be adapted to motion. It is hollow in structure in order that inspired air may be retained for cooling the heart and renewing the vital spirits. It is pennate in form, with seven lobes, of which the upper four are necessary to life, for if they are perforated by rheumy fluid from above the patient dies. The three lower lobes are less necessary to life, since the patient does not quickly die if they are perforated by fluid through *stillicidium*. The lung moves with a twofold motion, by which in diastole there is expulsion of air into the heart and in systole there is a discharge of wastes; and moreover, by this motion the lung is enabled to flagellate the heart at frequent intervals, thereby cooling it, and therefore it is called the flail of the heart.

The trachea is an organ which is firm and dry in complexion, hard and solid in substance, dense in constitution, long and round in shape. It arises in the lung and terminates at the base of the tongue. It is firm and dry of complexion, because firmness and dryness have a motion constricting the parts (to the brain)[1] and drying them and thus consolidating them, by which it can better resist external injury. In substance it is hard and solid, and in constitution it is dense, on account of the above-mentioned qualities and for the same reason. In form it is

[1] Literal version of an obscure and probably corrupt passage.

long and round. It is round because if it had angles it would retain waste matter and this would do harm. It is long and tubular in order that air may run freely to the spiritual organs and that wastes gathered there may be expelled. It arises in the lung for reasons described in the last paragraph, and it ends at the base of the tongue in order that the air which it carries may be utilized by the nine vocal organs in producing the voice.

The uvula is an organ situated in the palate above the trachea. It is red in color, broad above, and conical or pointed below. It is called uvula because it is shaped like an udder. It is the only outlet of the brain having an opening by which it serves the animal and spiritual members. It is wide above and narrow below; wide above in order that it may freely receive the excess phlegm, and narrow below in order that the phlegm may not flow suddenly into the spiritual organs and thus cause harm. The uvula has an opening continuous with the nostrils, by means of which people sometimes for a joke put a thread in the nose and spit it out from the mouth.

There is also another organ, called epiglottis, which acts in conjunction with the trachea and oesophagus, and is made in the shape of a finger. When food or drink is taken into the oesophagus, the epiglottis opens and bends toward the trachea and closes it. It does the opposite when one speaks, so that if a person happens to speak while eating, something will run down his trachea and impede the inspiration and expiration of air and must be gotten out the same way; otherwise the patient would suffocate.

There are also organs called glands, some large, others small, others medium-sized. If rheumy humor reaches the larger glands it causes a disease called *branchus gaballina.* If it flows to the smaller it causes *branchus minor.* If it flows to the medium-sized glands, it causes scrofula, which is so termed because almost invariably more than one gland becomes enlarged, just as a pig (*scropha*) almost always gives birth to more than one foetus.

Having discussed the spiritual members, let us speak next of the organs of nutrition, and first of the liver, which is the most important. But since the liver has subservient members, such as the mouth, oesophagus, and stomach, we should deal first with these. The mouth acts in the manner of a mill. The teeth represent the mill-stones and the tongue plays the part of the miller, for just as grain is received into a mill, so is food taken into the mouth; and in the same way that the grain is cast by the hand of the miller under the grindstones (*molares*) to be ground, so is food cast by the tongue beneath the molar teeth to be masticated. Note that the teeth are of different kinds. There are 24 teeth called maxillares or molars, 12 on one side, 12 on the other, 6 above and 6 below. There are other teeth called canines, 8 in number, 4 below, 4 above; and thus altogether there are 36 teeth in the mouth.

The oesophagus is fleshy inside and membranous outside; it is long, round, and tubular, beginning at the base of the tongue and ending at the upper orifice of the stomach, and it is the pathway of food and drink. It is called oesophagus from *ysos,* which means "equal," and *phagin,* which means "to eat," for it receives food and drink equally and transports them to the superior orifice of the stomach.

The stomach is cold and dry in complexion, hard and solid in substance, dense in constitution, long but more or less rounded in form, hollow and villous inside, smooth and even outside. It is formed of two layers and has two openings, one below and one above. In complexion it is cold and dry, because frigidity and dryness are concentrating qualities and reduce parts to solidity. The stomach is hard and solid and dense in constitution, so that it may retain the food and drink while the first digestion is performed. It is long and rounded in shape, because if it were markedly cavernous it would tend to retain undigested food. It is villous inside, in order that what is taken into it may not be discharged at once, but will be held and digested, and what is necessary will be retained. It is hollow in order that it may better contain food and drink. It is formed of two layers, so that if one breaks from overdistention, the other will still hold. It has two openings, one below, the other above. The lower opening is cavernous and is directed toward the liver. The upper is nervous and is turned toward the heart. The lower orifice is fleshy, in order that digestion may profit by the qualities there located, because flesh is warm and moist, and warmth and moisture greatly aid digestion. It has the liver below it like a fire underneath a caldron; and thus the stomach is like a kettle of food, the gall-bladder is the cook, and the liver is the fire. The upper orifice is nervous, so that it may feel its emptiness and become hungry, and when full it may perceive its repletion and cease to hunger. The heart is above it in order that it may aid digestion. We usually speak of a triple digestion, of which the first step is the taking-in of food and drink. The second is the liquefaction of the juice in the liver, where the generation of the four humors takes place; and the third is that of the blood in the veins, by which ultimately flesh is created where flesh is needed, bone where bone is needed, and so forth.

In the human body there are six intestines. The first is called duodenum, the second jejunum, the third *orbus* or *monoculus* or *saccus* (all these words have the same meaning), the fourth ileum, the fifth colon, the sixth *longaon.* The first is called duodenum because it is as long as 12 fingers' breadths, the second is called jejunum because in dead animals it is found empty; the next part is called *orbus* because of its one aperture, and *monoculus* for the same reason; it is also called *saccus,* because like a bag it has but one opening. The ileum takes its name from *yle,* which means "confusion," because that intestine is formed of com-

plex tangled coils. This intestine is the seat of iliac passion. The colon is called "colander" because the feces are strained there; it is the seat of colic passion. The *longaon* is so called because it is attached along the spine. It terminates at the anus, and thus in a certain chapter it is called "exit anus." But note that there is really but one intestine, bearing different names in its different parts.

There are eight mesenteric veins, of which the first arises in the fundus of the stomach, the second from the pylorus, the third from the duodenum, and five others from the jejunum. These eight veins unite near the hilum of the liver to form a large vein called *vena ramosa* or *lactea porta.* The term vena ramosa is conventional rather than descriptive, however, just as the trachea arteria is not arterial in fact but in name only.

Food is taken into the mouth and by aid of the tongue is masticated between the teeth; then it is carried by the oesophagus into the stomach. There it is modified by the action of heat and is changed into another essence. After this, the purer portion is partly retained by the stomach for its own nourishment, and the rest is carried to the hilum of the liver by that mesenteric vein which is connected to the fundus of the stomach. The impure portion descends to the pylorus and is again separated into pure and impure. The pure portion is in part carried to the hilum of the liver. The impure portion descends to the duodenum and there it is further modified and the pure separated from the impure, as we have described before. The impure portion is carried to the jejunum and there the first digestion, which began in the stomach, is fully completed, the pure nutriment being carried to the hilum by the five veins of the jejunum. The impure remainder passes through the other intestines and is at length rejected through the anus. The pure juice thus produced by digestion and carried by the mesenteric veins is called *succositas tisanaria,* from *"ptisane,"* or barley-water, because the juice resembles such a decoction in color. The mesenteric veins are so called from the word *media,* because it is by their mediation that this juice is carried to the hilum of the liver; or else the derivation is from *mensa,* because the juice is carried by them to the hilum as if to a table, so that the second digestion may be performed there and the four humors generated.

Opinions differ as to the generation of the four humors. Some say that the blood alone is generated, in form as well as substance, in the liver; the other humors are generated there in substance, but in other places as to form. If it be asked why the blood alone is generated there in form as well as in substance, it must be answered thus: the blood alone is the offspring, guardian, and conservator of nature, for it nourishes, guards, conserves, and repairs the members. The blood has also favorable qualities, such as fatness and moistness, which promote digestion, and for this reason it is retained in the liver long enough to be

created in substance and in form. The bile, however, is made there in substance only, because, due to its bitterness and irritating qualities, it is transported through its ducts to the gall-bladder and there receives its special characteristics; for the bile is not necessary to the members, except in so far as it promotes appetite, which is increased by heat and dryness. On account of this burning heat and destructive dryness, the bile is carried away from the delicate tissues of the liver, in order that it may not harm them. The black bile, which is of harmful nature because of its injurious qualities and coarseness, which are hurtful to the delicate substance of the liver, is carried by its ducts to the spleen and there undergoes specific differentiation; and it also is unnecessary to the members, except as it promotes retention by the effect of its coldness and dryness. The phlegm, on account of its coldness, which causes indigestion, is driven to the stomach, to the lung, to the brain, and to the joints, and there receives its specific differentiation; nor is it necessary to the members, except as regards the expulsive virtue with which it is endowed by its coldness and moisture. Those who say that the humors are generated in the liver in substance, but elsewhere in form, are willing to confirm the authority of Isaac and Theophilus. Isaac says in his *Particular Diets,* regarding the generation of humors, "the lung takes over what is mild and pure, but what is of injurious nature is taken up by the spleen." Theophilus says: "After the formation and perturbation of blood therein, the lighter parts tend upward, but the red bile is taken through the bile-ducts to the gall-bladder." Others hold that the four humors are generated in the liver both in substance and in form. When the humors are generated in the liver, they immediately receive substance and form; but although they can be seen, their form can not be discerned on account of mixture and confusion. When, for instance, the bile is transported to its place in the gall-bladder, it does not there receive any form or special differentiation, but the form which it had already received in the liver at last becomes manifest. The same explanation holds good for the other humors.

The same opinions are held about the urine. Some say that it is generated, in substance, in the liver, but being urinous and harmful to the liver, it is immediately taken by the capillary veins to the *vena chilis,* and thence to the kidneys, where it drains through the ureters into the bladder and there receives its specific differentiation. Others say, on the contrary, that it is generated in form as well as in substance in the liver, as we have said above with regard to the humors.

The liver is an organ which is warm and moist in complexion, delicate and soft in substance, slight and spongy in composition, and lobate in form, having five lobes. It is hollow within, but outwardly convex or crested, and formed like a letter C. It is protected by a capsule. It is warm and moist in complexion on account of the second digestion, which

is performed in it. It is delicate and soft because there is much blood in its substance. In composition it is light and spongy, so that it may retain blood to promote nourishment of the body. In form it is lobate, so that its lobes may embrace the stomach and by their warmth aid the first digestion. It is hollow within, where the succositas tisanaria is collected, in order that the four humors may be formed there. It is shaped like a letter C, or like the new moon; and the hilum of the liver is said to lie in the curvature. It is protected by a capsule which serves to guard it from the hardness of the ribs. It is the spiritual instrument of the second digestion, because the second digestion is performed in it.

Note also that the eight mesenteric veins unite at the hilum of the liver and form a large vein, called vena ramosa, for the reason (as Galen says in the *Pantegni*) that before leaving the liver it is divided into five branches which go separately into individual lobes of the liver. Note also that vena ramosa is a conventional term, just as the trachea is nominally called trachea arteria. From the vena ramosa there arise certain five venules like hairs, which are called capillary veins, and which leave via the hilum of the liver. As they leave they unite and form the *vena chilis,* which lies close to the dorsal spine from above downward. It is called vena chilis from *kilos,* which means "juice." Through this vein juice is borne to the entire body. The vena chilis breaks up into three branches, two small and one large. The two smaller reach and enter the kidneys, to which they carry the urine with the blood. The blood which they carry there remains as nourishment for the kidneys, while the urine is drained to the bladder through other veins called ureters, or veins of the urine. Thereafter the urine passes down out of the bladder through the penis and is discharged. Note also that the nutritive blood and animal spirits are borne by all the veins generally. The larger branch of the vena chilis goes to individual members, including the stomach, heart, brain, and the lower members. Two veins called varicæ also arise from the vena cava; they go down as far as the backs of the knees and when they are cut obliquely they make men varicose, that is, shut. From the vena chilis arise two other veins called *salvatellæ,* one of which goes to the right foot, the other to the left, terminating between the little toe and the next adjacent; when they are incised they purge away black-biliary blood. Four other veins called *saphenæ* arise from the vena chilis, two going to the right leg and two to the left, down to the soles of the foot. One is mesial, and the other lateral. When the inner one is bled it relieves pains of the stomach, kidneys, intestines, and uterus. Bleeding of the outer one relieves sciatica. Five other veins called *haemorrhoidæ* arise from the same vein and terminate about the pudendum; through these the black-biliary blood flows, just as the menstrual blood flows through the uterus.

A number of slender veins like hairs arise from the vena ramosa and leave by way of the crest of the liver. As they go out they unite and form a large vein called *vena cava.* This vein, as mentioned above, divides into two veins, one of which goes upward, the other downward. The one which goes upward divides into two branches, one of which passes from below into the right auricle of the heart, as we said when we discussed the spiritual organs. The second and remaining branch is divided into numerous branches, two of which pass to the upper arms, one to the right and the other to the left. The one which goes to the right divides into several branches, some of which ascend through the neck and temples to the brain; others pass down the arm into the hand.

Three of these latter are important, namely, the cephalic, median, and hepatic. The cephalic vein is situated in the upper part of the arm; it is called cephalic from *cepha,* which means "head," because it is incised for pain in the head. The median is so called because it is midway between the cephalic and hepatic; incision of this vein relieves pains of the whole body. The hepatic, or basilic, or fundamentalis is so called because it arises from the foundation of all veins, that is, the liver. The same statements apply to the corresponding veins of the left arm.

Another vein arises from the vena cava, crossing the middle of the lung and passing to the right forearm. This when incised relieves asthma and other disorders of the lung. Two veins arising from the same vein go via the spleen as far as the axillæ and are called *venæ tittilares,* because when they are cut across they cause a man to die in a fit of laughter. There are two other veins which pass through the arms and terminate between the little finger and the middle finger. These are called *salvatellæ,* and incision of these is good for quartan fever, mania, and melancholia. Two other veins arising from the vena cava go to the ear and are called *parotides,* from *para,* which means "near," and *otis,* which signifies the organ of hearing, for they terminate near the organ of hearing and thus reach the optic (!) or auditory nerve. For this reason overdistention of these veins leads to compression and stoppage of the optic nerve and thus causes deafness; but such deafness is cured by flow of blood from the nose. From the same vein certain veins arise and are distributed to the brain, which are called "juveniles," because, as Hippocrates says, if they are cut a man can no longer produce sperm. Other veins arising from the vena cava ascend laterally along the trachea and are called *venæ organicæ,* or *pneumaticæ,* for when anyone tries to sing they become dilated and can be seen; and if one becomes hoarse, drainage of humors through these veins clears up the hoarseness. Note that all these veins unite at the brain, and in conjunction with the arteries form an arterial net, which immediately surrounds the brain.

The vena cava, as we said before, divides into two branches as it leaves the liver, one of which goes upward, the other downward. The one which goes downward divides into numerous branches, some of which go to the stomach, others to the intestines, others to the kidneys, others to the legs, just as we said of the vena chilis. Through these veins nutritive blood and animal spirits are carried to nourish and comfort the members.

All the foregoing veins are found in both sexes; but there is another vein which is found only in women, called *kiveris vena,* that is, the female vein. This vein begins in the liver, and as it leaves it divides into two branches, one of which goes upward, the other downward. The one which goes downward divides into two branches, one of which enters the right horn of the uterus, the other the left; and through these branches the menstrual blood is carried into the uterus, to be discharged later through the portal of the uterus. The branch which goes upward divides into two branches, one of which goes to the right breast, the other to the left. When the os uteri closes after conception, the menstrual blood is retained and part of it is transported by these veins to the breasts, where it is modified and transsubstantiated into the essence of the milk, which provident ministering nature provides and prepares as nutriment for the foetus when it sees the light. The remainder of the menstrual blood is taken to nourish the foetus while it is in the maternal uterus.

Enough has now been said about the more important and better-known veins, but there are also in the human body infinite numbers of veins which are unknown except to God alone, to whom nothing is unknown. Note that the blood does not nourish while it is in the veins, but oozes through the veins into the fountains. The fountains are hollow and petrous regions in the body where the blood is modified by the action of natural heat; here the third digestion is carried on and the bony materials are changed (in substance and in form) into bone, the fleshy into flesh, skin-forming substance into skin, and so forth.

Next in order are the genital organs, among which the testes come first, as the most important. The testes are hot and moist in complexion, delicate and soft in substance, slight and spongy in composition, round and oblong in form. In men they are large, in women small. In both sexes they generate sperm. They are situated in the *oscheum* or testicular pouch. They are hot and moist in complexion because these qualities favor the digestive force, which assists the formation of sperm. The reasons for their substance, composition, and so forth can be deduced from what has been said above. The testes have an attachment to certain nerves which bifurcate; these are called *didymi,* or "doubtful," because it is doubtful whether they arise from the testes or from the *zirbus* or *siphac,* into which they pass. The *siphac* or *zirbus* is a membrane which

surrounds the intestines; and when it breaks the intestines drop into the scrotum and this is the cause of rupture. Sometimes it happens that one or both testes are drawn up by the nerves by which they are bound to the intestines, and thus they do not appear in the scrotum. There are other genital organs called seminal ducts, which are between the testes and the penis and carry the sperm formed and generated in the testes into the minting-place of conception. There are three different opinions as to the generation of the sperm; Hippocrates says that it is formed, in substance, in the brain; Galen that it is formed in the liver; others say in the whole body. All these opinions seem to be more or less correct. The statement of Hippocrates was based for the most part upon what was said above, to the effect that a man with the *venæ juveniles* cut can no longer form sperm. (The juveniles are certain veins which have a connection with the brain.) When Galen, on the other hand, spoke as he did, he was thinking chiefly of the origin of the sperm, for all members get the nutriment from which they are formed from the liver, where it originates. The opinion of the others referred to the situation and essence of the sperm, for the testes possess an attachment to their cooperating organs, the nerves, veins, and arteries.

The uterus is cold and dry in complexion, fibrous and dense in composition, oblong and round in form. It is hollow and villous within, smooth outside, divided into seven cells, and has two openings. It is cold and dry in complexion, in order that through these centripetal qualities it may acquire hardness and solidity. It is dense and fibrous, in order to resist the kicking of the foetus. It is round, in order to avoid angles in which harmful waste products might collect. It is oblong to accommodate the foetus. It has two orifices, one at the bottom, the other inside. The lower one is fleshy and less fibrous, the inner one more fibrous and less fleshy. The lower orifice is patent, the inner is patulous. There is a difference between these terms; "patent" is that which is sometimes open and sometimes not, while "patulous" is that which is always open, although sometimes it closes. The lower orifice is called *vulva,* from *volo vis,* or from *volvendo,* or from *valva,* which is a door, for it is the portal of the uterus. The uterus is divided into seven cavities, three on the right side, three on the left, the seventh in the middle. In these cavities the foetus is generated, but there are diverse opinions about its formation. Some say that male infants are generated in the right cavities, females in the left, hermaphrodites in the middle. Others say that both males and females are generated on the right side and also on the left; but they also say that a male generated on the left side will be a weak and effeminate man, and conversely a female generated on the right will be mannish and rough. In the middle a so-called hermaphrodite will be generated, that is to say, a strange monster having both male and female organs. There are others who

take into account the proportions of the sperm, saying that when the male and female sperm are mixed in the uterus to form the foetus, if the male sperm is present in greater proportion it draws the female sperm to its own likeness, and a boy will be conceived; if the contrary it will be a girl. If both are equal, an intermediate creature will be conceived, as already said. The same thing can be seen in water and wine. If wine in greater quantity be mixed with water, it draws the water to its own likeness and makes wine; and if the opposite, it makes water; but if they are mixed in equal proportions an intermediate product is formed which is neither wine nor water, but differs in number and species from each of the constituents. Those who say this get the parallel upon the authority of Aristotle, who says that if you join any two equal things similar in power, each breaks down and forms an intermediate substance, but if they are unequal in power, the more potent dominates.

It is customary to ask why women display more ardent desire after conception than before, and the following is the reason usually assigned: Constantine says that the os uteri is closed after conception. You are not to understand that it is closed immediately after the injection of the sperm from which the foetus is generated, but rather that it closes during the time in which the foetus is growing; otherwise we should be contradicting what has already been said. Twins are never generated from a single injection of sperm; there must be two injections to generate twins, and so forth. While the foetus is growing, the inner opening of the uterus contracts because of the weight and closes so tightly that not even the point of a needle can enter. The sensitive fibers touch each other, and feeling themselves empty they have a joyous desire for repletion. Women wishing to satisfy this desire receive the masculine sperm, but on account of the constriction in the region the sperm can not reach the sensitive fibers in large quantity. It comes about thus that the cold and dry fibers, perceiving the sperm, which is warm and moist, develop greater desire and excitement. It is also usual to ask why women show greater desire than men. This is for a three-fold reason, namely, the complexion, the substance, and the composition of the uterus; for it is the law of solid and subtle bodies that they do not readily undergo change, but slowly give up what they have taken on, while subtle bodies quickly undergo change and readily relinquish it, as can be seen in straw and in iron. Therefore men, who are warm and dry in comparison to women, are quickly aroused and quickly relinquish desire, while women, on account of their own complexion as well as the complexion and solidity of the uterus, are not easily aroused, but once inflamed their desire does not quickly subside.

ANATOMIA VIVORUM (ANATOMIA RICARDI ANGLICI)

[Translated from Töply's text, with modifications based on the Giunta Galen]

1. Introduction

A knowledge of anatomy is necessary to physicians in order that they may understand how the human body is constructed to perform different movements and operations, and how the body is formed in many diverse parts, and endowed with a soul from which proceed noble powers and numerous virtues, by which it is ruled and preserved and protected from corruption and sudden accident. Since no function can be performed without organs adapted to its service, there is of necessity an adaptation and preparation of the numerous organs which form the human body, by which functions are carried on and the intended ends are reached. Again, no function can be preserved or even begun without various kinds of aid, and therefore special organs must be specially formed of diverse parts. The organs and their parts are called "members" by physicians, and they are generated from suitable humors as the humors are generated from the food. Some members are simple, others compound. The simple members are those of which any part, however small, is like all other parts in name and in definition, for instance, bone and flesh. The compound members are those of which the parts are not all alike in name and definition, for instance, the hand and the face.

2. Consimilar Members

The first among consimilar members is bone, which is hard because it is the framework of the body and sustains it when in motion; it varies in hardness, now more, now less. Next is cartilage, softer and more flexible, yet harder than the other tissues; the reason of its creation was to facilitate connection of bones to the membranes and muscles; for if soft parts were joined directly to hard parts, great pain would be caused as a result of a blow or by a fall compressing the soft against the hard; therefore the heads and sockets of the bones were invested with this intermediate substance, as for instance, in the scapula, in the ribs, in the epiglottis, in the ensiform, and in many other places. However, this is not the only function of cartilage, which has many other uses; for instance, the ensiform cartilage serves to protect the entrance to the stomach. Where there is friction, as in the joints, cartilage makes better contact; yet it may be broken as a result of its brittleness. Also, cartilage at times supports an elongated but weak part which would otherwise lack support or reinforcement.

3. The Nerves

Next are the nerves, which arise like twigs from the brain and spinal cord, to serve as messengers or agents. They are composed of firm and flexible material and are difficult to separate. Their function is to carry sensation and motion from the brain to other parts and to strengthen the whole body through which they pass; also to spread out and form investments of the insensitive organs like the liver, spleen, and lung. For these members do not possess feeling, but they are provided with an accessory nervous investment; and when they are swollen by abscesses or inflation the pressure and weight of the abscess or the enlargement of the swelling reaches the investment or its roots and is perceived.

(Next follow nine similar paragraphs dealing with the tendons, ligaments, arteries, veins, membranes, flesh and glands, fat, marrow, and the fluids of the eyes.)

13. The Spinal Cord

The spinal cord is thought by some to be marrow, but Aristotle says that it is not marrow, because it possesses firmness, which is not a quality of marrow. He said also that its function is to pass through the spine like a ligament, helping unite the vertebræ and everything which arises from them; but subsequently another use of it has been discovered, for it descends from the brain to provide sensation and motion in the members other than the head.

14. On the Virtues, Origin, and Structure of the Simple Members

These are the simple members of the human body, in each of which are seated forces to guard and care for its functions. There are two kinds of necessary forces, motive and digestive or maturative. The doctors divide motive forces into three: appetitive, which draws required material to the proper place; expulsive, which expels unnecessary material from a place; and retentive, which retains in a place whatever is needed. . . . I say that the motion of every consimilar member is either from the sperm or from the blood. From the sperm everything is generated except fat and flesh, which are generated from blood. According to the physician, male and female sperm are intended for different purposes. The purpose of the male sperm is to give form in the likeness of that from which the sperm comes; the purpose of the female sperm is to receive form in the likeness of that from which the sperm comes. From the male sperm, therefore, come spirit and creative power and form; from the female sperm come foundation, generation, and material. Flesh to fill the vacant spaces between organs is generated only from blood clotted by heat and dryness. Fat comes from fluidity and oiliness, which coagulate when cold and dissolve when heated. Anything generated from blood can be renewed after loss; and anything generated from blood in which the power of the sperm persists can be renewed

after removal, as, for instance, the teeth in childhood. Also those parts which are allied to blood in complexion do not lack nutriment, because of the plentiful conversion of blood, which is immediately turned into nutriment. In the case of those parts which are derived from sperm, which are unlike blood in complexion, it is necessary for blood to be turned by plentiful conversion into nutriment for them, in orderly fashion; for this reason there are in certain members numerous foramina in which nutritive blood lingers and stagnates and is converted little by little into the semblance of the part. However, these foramina are distinct from the flesh.

Although many of the foregoing parts are called "simple members" by doctors, yet they are not without complexions and textures. For instance, the veins and arteries and all membranes are composed of fibers or threads arranged in orderly texture, just as we see sometimes in artificial fabrics. This is for several reasons. First, all motion is carried on by strands; voluntary motion is performed by fibers distributed in muscles; and natural motion, which is attractive or attracted, retentive and expulsive, is carried on by the strands of which the natural vessels are woven, as, for instance, the stomach, intestines, veins, arteries, and nerves. Just as in artificial fabrics some threads run in length, some in breadth, some transversely, so it is also in some natural fabrics. The fibers which stretch longitudinally are called attractive; those which stretch latitudinally are expulsive and constrictive; those which descend transversely serve for retention. Then there are also restraining fibers placed in the middle to fit their various situations, to prevent excessive velocity of the expulsive and attractive movements; for motions should not be hasty, but should occur with a certain succession and gradation. Sometimes all these kinds of fibers occur at once in the same tunic, sometimes in different tunics; and when they occur in different tunics, then those fibers which stretch laterally are found chiefly in the outer layers and the other two kinds of fibers are found chiefly in the inner layers, but the longitudinal fibers tend toward the internal surface. This separation of the fibers is specially intended to cause better and quicker motion. In organs in which there is long retention of material, the retentive fibers are more decidedly mixed with the expulsive, as in the stomach, uterus, bladder, and caecum, all of which have spacious cavities. This is not the case in organs in which there is no such strong necessity, as, for instance, the intestines, in which the need is rather for much attraction with strong expulsion.

15. The Vessels

Next come the vessels, which are parts of members having a fibrous structure. Some of them have one coat and others have two. Those which have one coat are those in which there is no fear of damage from what is inside them, because the latter is soft and quiet, as, for instance,

the quiet blood which resides in the veins. For this reason neither the veins nor the bladder have any need of complicated coverings, except in emergencies; but the body attempts to furnish a margin of safety whenever possible, and hence there is a providential creation of multiplex tunics of members in which frequent and serious emergencies may occur, for the vessels in which there is violent and continuous motion must be strong and thick to provide protection and security; otherwise they might be torn apart by the movement of their contents. Besides, it is necessary to provide against the great danger of loss and dispersion of the violent material when it is of noble substance and especially when it is the peculiar vehicle of the soul; and this consideration had to be particularly looked after when the vessels were constructed. The materials referred to are spirits and blood, which are concealed in the arteries; they are called the first and best treasury of nature, and they are the cause of the multiplication of the coats of arteries. The third cause is the vigorous attraction and expulsion, which require a special organ or instrument, for each member is made separately and without mingling (of function), as demonstrated, for instance, by the stomach and intestines. The fourth cause is the variety of composition which arises from various sources and has various ends in view, and is best provided for by parts of diverse complexions. Therefore, since such operations are inevitable in every member, nature prefers to distribute them and to prepare an instrument appropriate to each operation by which it may best act. As an example, take the stomach, in which there is an operation which needs for completion both a fibrous and a non-fibrous organ and also a digestive operation which is best carried out in a fleshy organ. Therefore nature arranged both a fleshy and a fibrous coat, providing the latter for tempering and distempering unprepared foodstuffs, the former for maturation of the material undergoing digestion. Nature, however, arranged the position of these coats with provident care, placing the fibrous and sensitive coat inside, the fleshy digestive coat outside, so that the action of the digesting layer may take place without contact with the material to be digested, while the mechanical action is performed in contact with the material involved.

(16, The Skin, is omitted.)

17. The Organic Members

There are some organs which receive service and are royal, and others which do service to the former. The royal organs which receive service are those in which is fullness of life, and they are the seats of the forces of life and of intellect, and they are official. There are seven internal royal organs, four of which are preeminent in importance and authority, namely, the heart, brain, liver, and stomach, and these are most important because they are the source of the vital forces ruling the animate body

of man. After these in importance are the two testicles, the kidneys, and the bladder. These seven are divided like the planets, and if we add the lung and spleen we find eight, comparable in importance to the eight spheres and divided like the eight orbs of the world. Some of the organs which serve the royal organs are external and visible, namely, the eyes, ears, hands, and feet; others are internal, such as the epiglottis, oesophagus, trachea, intestines, and so forth. God ordained also flesh and nerves, kidneys, testicles, vulva, the membranes of the heart and the thorax, the uvula and epiglottis, the tonsils and the tongue.

The blood emanates from the liver and its place is in the veins and in the heart. Its power is exerted in the surface of the body and in the anterior part of the head, and consequently its properties are laughter, joy, desire of coitus, and much sleeping; in the stomach its properties are speed of digestion and ease of penetration; and in the whole body its property is to change its substance readily into flesh.

Glorious and Excellent God also created the brain, lung, and all cold and moist members of the body from phlegm; and he made phlegm the beginning and special element of these organs. He divided it into divisions like those of the waters upon the earth and the division in the air made by clouds. Thus there is a part of the phlegm which runs in the pulmonary passages and is mixed with the air, aiding to prepare it to stimulate the heart and to strengthen the respiratory force to expel it, for retention of it may be the cause of combustion of the heart. It is this portion of the phlegm which rises from the lung to the brain and by its composition descends thence as dew descends from the air near the earth. Its power is exerted in the posterior part of the brain and in the thorax, and it affects the conduct, favoring chastity, poverty, piety, desire of coitus. It also affects movement, producing sluggishness, taciturnity, gravity, and slowness of response. In the body it tends to paralysis, tremor, and debility. Its action in the stomach is to produce chilling by the sharpness of the food, drink, and other material brought into the stomach, the heart, or other part of the body, because the expulsive force is strengthened in it, like by like and similar by similar.

18. The Gall-Bladder

Almighty and Glorious God also created the gall-bladder, which is hot, dry, and fiery. It is the seat of the yellow bile. He placed it near the liver to aid the latter in the defecation of food, and he put the place of action of the yellow bile in the top of the head, because of its lightness, subtlety, altitude, and elevation. The bile is exhaled from the two ears because they are formed from it, and its nature is similar to that of the ears, because it is hot and dry. It flows through the body with the blood, because the blood and bile are fitted to one another like the fitness of the oil to the lamp. Its function in the stomach is to attract food and to aid digestion and the discharge of the feces. It presides over moral

virtue, and among its incidental effects are inconstancy, fury, subtlety, acuteness, skill, boldness, elation, desire of coitus, memory, and quickness of response. From it the whole body derives heat and dryness.

19. The Bones, Cartilages, Hairs, and Nails

God related the bones, cartilages, hairs, nails, and ligaments to black bile; for all these members, made of congealed earth and deprived of sensation, are derived from the melancholic humor, which is located in the spleen. Its force is exerted in the organs of vision and in the left side of the body, and it promotes taciturnity, cogitation, gravity, lamentation, fear, solicitude, and pusillanimity. In the stomach it has the property of retaining and exciting the appetite. From the black bile the body acquires coldness and dryness of flesh and immobility according to the degree of its domination.

(20, Principal Members; 21, The Heart; 22, The Substance of the Heart; and 23, The Firm and Dry Parts of the Heart, contain matter which is largely repeated in 42.)

24. The Position of the Heart

The heart is situated in the middle of the chest because conditions are more temperate there. It inclines a little toward the left side in order to leave more room for the liver, for it is better to give space to the liver than to the spleen because the liver is higher. There is a second reason for its inclination toward the left, namely, to prevent excessive heat in the right side; for the right side might be overheated because of its nearness to the two sources of bodily heat, while the left might be cooled down because it is removed from those sources. On this account it is better for the heart to incline toward the left in order to warm the left side, especially since the spleen itself is not very warm. There is a third reason, namely, to make space for the hollow vein which ascends from the liver (or descends to it).

The heart is situated in the middle, in order that it may be equally near to all surrounding parts and may easily gather assistance from them, and that it may be everywhere surrounded by the organs which serve it.

God measured the capacity of the heart, making it sufficient without excess or insufficiency, so that it should not be overweighted by too much blood nor break nor choke in its extremities because of too little contents. From it the arteries originate, all ligaments are suspended, and all power is derived. However, excess and insufficiency of the heart occur at times, but I say that exaggerated size of the heart is not the cause of boldness, as some assert, nor is smallness of it the cause of fear and trembling. Many animals have hearts which are large out of proportion to their bodies, but these animals are mostly timid and fearful, because the whole heart is not warmed, but is left cold and empty, and

the animal is timid. On the other hand, certain animals have small hearts, and these are bold, because there is much warmth in their hearts and this is confined by the narrow space and boils fiercely. But the animals which are boldest are those which have both large hearts and much heat. The heart is nourished by its natural forces and their motions, namely, diastole and systole, with two intervening rests, for there must be a rest between two contrary motions. In all this nature employs a sort of musical art, for just as music is formed by the succession of high and low notes properly and rhythmically arranged, so in the arrangement of pulsation in the heart there is a systematic arrangement of the rate and an alternation of strength and weakness of pulse-beat and rest. When all these things run properly and in order, then the regimen of the body is sound and everything goes on in safety and quiet. But if these events exceed their natural proportions, then there is a disturbance of nature, and the extent of disturbance is proportional to the deviation. The heart-beat is therefore either a harmony arising from the sources of the bodily constitution, or else discord caused by factors leading to excess or decrease, as is manifest in the fluctuations of the mind, such as fear, hope, sadness and joy, luxury, chastity, greed, and generosity; also in the bodily ills, cold as well as hot, moist, dry, and so forth.

The limit of movement of the heart is determined by contact with the tunic or membrane outside it which is provided as protection and guard. There is a space between the heart and this membrane where the artery originates and also at the base of the heart, so that it can dilate without suffocation and contract in ample space. Its movements cause movements in the arteries, its dilatation causing them to dilate, its contraction causing them to constrict. (Some, however, say otherwise, referring to the action of bellows, but experience manifestly contradicts them.) To prove this, if you place one hand over the heart and the other upon an artery, you will observe depression of the heart to coincide with depression of the artery and elevation of the heart with elevation of the artery. It is also true that a thin, slow, and small pulse causes sadness, which would never occur if the arteries were dilated by contraction of the heart. Also, according to this other view, a round and swollen face ought to occur with sadness rather than with anger, and an enlarged pulse with humility rather than with pride, and a depressed pulse with pride rather than with humility; but in fact the opposite always happens, and this shows that elevation of the heart results in elevation of the artery and constriction of the heart causes constriction of the artery. The advance of the vital heat begins at the fundus or small end of the heart where it originates, thence proceeding laterally and outwardly after the pattern of the heart. It then leaves the heart, is taken up by the vessels, and is carried over the whole body, even to the

extremities, where it is distributed. This motion is in truth the primal motion, and the pattern of the heart thus followed is the source of all patterns of the body. Isaac, however, holds views widely different from this.

The whole animal body is thus developed by nature, as it were, from one primal root, but on account of the diversity of important functions which arise from its root it was necessary to create diverse organs without any commixture, by which they could be prepared and in which their successful working might be more easily sustained by separation of their actions; for if these organs were united into one, the confusion of forces would cause internal disorder and impediment. It is better, then, for these numerous and diverse receptacles to be separate and for the more important bodily functions to be specifically developed each in a single organ. For this reason the brain, liver, lung, and stomach were created as individual branches of the main root. For above the main root other branches grow in fellowship. As in things which grow in the earth, the root is the first and lowest part, and then ascending branches appear; and thus the plant progresses vigorously and does better than it promised at first. So also in the animal, members develop above the root, which is the heart, and these are comparable to the branches of plants, for nature sets up in them various functions, according to the need of the respective parts of the animal.

Nature's solicitude is of double kind, consisting first of restoration of used-up or injured parts and second of care and protection of the restoring parts. Thus there is a double exit from the heart and a double pathway of restrictive force to the outward parts. But she prefers to conceal her inner workings, which are buried with her furnaces and nodes in two spaces prepared by nature, the upper and the lower. They are separated by the diaphragm (the upper cavity is also divided by the central membrane of the chest) and the upper is the home of the heart and lung. In the lung is located the preparation and rectification of spirits before they enter the heart. Air is drawn to this part through the large tube and the nasal canals.

The lower cavity is the seat of the organs of nutrition; it is entered by way of the oesophagus, and into it the wastes are drained.

In connection with the air there is a branch, namely, the lung, upon which grow the trachea with its cartilage and the nasal canals; and in connection with the blood another branch sprouts, namely, the liver, in which the blood first appears; and subject to this are other branches, small in comparison with the liver, which are filters and are the seats of the heavy wastes of the blood. Above the liver is the stomach with its appendages (although these are also related in another sense to the brain and to the main root, the heart, on account of the excessive quantity of the blood of the stomach and of its appendages, and on account of

the quantity of its work or weight when it is full). Above the stomach is the oesophagus, which receives food from the mouth. Its function is the care and protection of the organs of nutrition. The growth of the whole structure is toward the exterior. Therefore it rises and ascends toward the uppermost part, which is the region of most importance in caring for the members, and in that place another branch grows in which very marvelous operations are carried on. This branch is called the brain. Above it are several other branches in which the five senses operate. These senses look toward the exterior, and in them irascibility and concupiscence are seated; and these branches are muscles scattered throughout the body, both inside and outside, and in the extremities, as in the hands and feet and in the head. The branches in which generation is seated are derived from the brain, according to Hippocrates; although according to learned men since his day they are supported and sustained on other primary branches by means of spirits from the primal root (i. e., the heart).

25. The Arteries of the Heart

From the left ventricle of the heart arise two arteries, one of which passes to the lung and there divides, in order that it may draw in air, and also it may carry directly from the heart the blood which is to nourish the lung, because the nutriment of the lung is carried first to the left ventricle, in which it is meliorated, and then is transmitted to the lung. This artery differs from all other arteries in that it has but one tunic, and therefore it is called *arteria venalis*. If you compare the firmness and solidity of the double tunic with the lightness and porosity of the single tunic, you will see that lightness and porosity and a single tunic are necessary here, because lightness and porosity facilitate dilatation and constriction and the filtering of that which filters from this artery into the lung, namely, thin and volatile blood, which is similar to the substance of the lung and suitable for it. This *arteria venalis* divides in the anterior side of the lung and is attached to it. It carries subtle and vaporous blood which is nearly but not quite completely digested, but there is no fear on this account, because of its nearness to the heart, from which there comes warm digestive force to convert the blood. There is also a vein from the right ventricle of the heart which enters the lung, having two tunics like an artery, for which reason it is called *vena arterialis*. Its first function is to permit complete refinement of the blood which filters from it, because this blood is not digested like that which is poured into the *arteria venalis*. For this reason it is necessary that the vein which carries it must be provided with thick tunics. Another function is to permit only the filtering of blood, which is thin and well heated, as nearly as possible like that which comes from the left cavity, because the latter is (as it were) a subtle spirit of great assistance to the lung in its movements.

The lung is thus made to serve as a receptacle for cold air, which then goes to cool the heart. If this air did not exist, the heart would burn itself up. For this reason, every animal which has much heat has also a large lung. The quadrupeds have large lungs; but the birds, which are of colder nature, have small lungs, because the inspired air is sufficient to supply heat to the spirits, so that some birds neither drink nor feel thirst, for the inspired heat suffices to their nature.

Galen says that air is not drawn to the heart to serve as nutriment, because neither air (since it is simple) nor simple water can become nutriment, because of the dissimilarity and distance between these substances and the nutriment. In truth, however, each of them is either a part of the nutriment or else aids the nutriment to become free. I say that air is nutriment to the spirits, and that both air and water are not simple substances but compound. The method by which the heart and its spirits are cooled by the air is by evacuation of the waste part of the burned-out spirit, which is a vapor rendered tense and almost on fire through its motion. This occurs especially because the air is cold in comparison with the expired vaporous heat. The cooling of the heart by the indrawn air is similar to the cooling of the stomach at the time it is being filled, by the movement and descent of the food (as the Philosopher says, "the empty stomach heats, the full stomach cools"), for the lung also has moving parts. The first of these is the trachea, next the branches of the *arteria venalis,* and thirdly the branches of the *vena arterialis.* To these is added the flesh, which is porous and soft, and created from very thin and subtle blood, by which also it is nourished and preserved. The lung is therefore porous and soft, tending to whiteness and having many passages; it receives air into itself and digests and expels waste substance from it. Just as the liver is made, in relation to the food, the lung also is soft in order to permit of its two motions, namely, attraction and respiration. In these motions it follows the thorax. The function of the flesh of the lung is to fill the veins and to unite their branches. Its tendency to whiteness is because of the domination of water over it, by which it is nourished, and because of its great coldness; for it is the seat of water by which the respiratory force is aided in the expulsion of hot vapors and by which air is aided to reach the heart quickly. The porosity of the lung fits it for the attraction and reception of air; for the air not only passes into the trachea, but also goes through the trachea into the body of the lung, and thus there is an obviously large amount of air in the lung. There is another advantage in its porosity, namely, that it facilitates constriction and expulsion. The lining is thus prepared for two motions, and on this account the lining expands with insufflation and constricts and closes with exsufflation. Its constriction follows the constriction of the thorax and its dilation follows dilatation of the thorax, as we have said, so that no vacuum

is formed. The same thing may be seen in a sponge which when squeezed in the hand is compressed into a narrow space, but if it is released and the air enters, the sponge dilates and takes up as large a space as before.

The lung is divided into two parts, by which we may consider it to be twinned in the same way that other organs are double in man. Although it is open to doubt whether the liver be double in man, it is double in fishes; a duplication of the brain is recognized in man, because man suffers from migraine, and also because when he is paralyzed one side suffers and not the other. The utility of the division of the lung into two parts is that there is no loss of respiration when one of the two parts suffers injury. Each division of the lung is further divided into two lobes, and on the right side another lobe is found which is not of much use in breathing, but serves as a bed for the vena cava ascending to the heart with nutritive blood. The second divisions of the lung, like the first, serve, as it were, as fingers in embracing the heart. The extra section of the right side is to fill up and equalize the space, because the heart deviates to the left side. The lung is insensitive and immobile in itself; we know this because no nerves penetrate it, and all sensation and motion is carried on by nerves. It is covered by a nervous membrane which provides it with sensation on the surface, as was foreordained. The lung itself is spread beneath the heart, sustaining and lifting it. It is hollowed out on the dorsal side and is doubled there in order to fit into the hollows at each side of the spine. It is also hollowed in front in order to embrace the heart more easily. Its greatest density is where the trachea makes exit. From this point it descends, gradually thinning out toward its lower end. Its greater density in the upper part is necessary to support the broad and dense upper portion of the heart, for which purpose it needs to be dense and soft above; but below it does not need this kind of denseness and is thinned out, because the heart also is relatively thinner and less dense. In this way the lung may be compared to the earth, which supports and guards the fruit just as the lung supports and guards the heart.

There are several reasons for the large size of the lung. One is to provide a quantity of air which will suffice for several pulsations of the heart; for if because of smallness of the lung the number of inspirations was equal to the number of heart-beats, then of necessity several very important properties of the lung would cease to exist, for instance, the prolonged emission of sound which is required in sermons, in addresses, and in singing; the breath could not be held in the presence of stinking or putrifying things, nor at the moment of swallowing. Indeed, both inspiration and expiration would be hindered, but this could not continue long. A large bulk of lung is also needed in order to provide a sufficient quantity of spirits when a person is submerged

in the waters. Some animals have lungs, others do not; those which have lungs are those which walk and contain blood. In fishes there are gills, and some other animals have canals and passages in place of lungs. The dolphin, the sea-hare, and other animals which are amphibious and which are called *cenealia* in Arabic, as well as fishes, breathe water-vapor through their gills, for a small amount of vapor suffices for them, since they contain a large quantity of cold. It is doubtful whether fishes breathe air, but fishermen say that when the dolphin sleeps on the surface of the sea they hear him snore. (Galen promised that he would discuss this matter.)

26. The Structure of the Eye

God placed the head at the upper part of the animal, and he did this chiefly on account of the eyes; and he made the anterior part of the head higher in order to put the eyes there. Like a scout looking all about him from a height for an army on the plain, the eyes survey the structures placed below. Certain animals with small, sloping heads have their eyes placed at the ends of nerves which they alternately put out and draw in. This is the case in the snail, in which these extremities are called horns. In other animals these projecting extremities can not be retracted, but they have adjacent organs of defense like two shields for the eyes; this is the case in the crab.

From the brain two nerves arise, each of which is surrounded by two membranes or tunics originating from the two *matres* or meninges; and these membranes pass into the two eyes and there dilate to surround and receive the humors. There is a crystalline humor, called *grando glacialis* by Aristotle, because it resembles a hail-stone in form and color. This is placed in the depth and in the middle for two reasons; because the middle is a safe and honorable place, and because in that position it can receive sustenance from surrounding structures. This humor has a spherical form in its posterior aspect, but is slightly flattened on the anterior side for this reason; if it were everywhere spherical, the image of the thing seen would slide over it and would touch it at one point only. Therefore the anterior surface is flattened so that the sight of small objects may strike it in numerous places. This humor is diaphanous and translucent in order that it may be receptive to all forms.

Next after the crystalline humor toward the brain comes the vitreous humor, so called because it is like melted glass. Its color, like that of glass, is intermediate between pink and white. It serves to rectify the nutriment of the crystalline humor and to make a gradation in the blood which is to be converted into the crystalline humor; for if blood in the red condition penetrated to the crystalline humor it would contaminate it and would make everything looked at appear red. It rises to the greatest circumference of the crystalline, making a hemisphere about it.

This humor has the same relation to the crystalline as the stomach has to the liver.

At the front of the crystalline humor, opposite to the vitreous, is the albugineous humor, which resembles white of egg, and which has multiple functions. It protects the crystalline from the rarefaction of the external air. It is also a superfluity of the crystalline, just as the hair and nails are superfluities of the animal and yet serve to protect it. This humor is placed in front of the crystalline in order to graduate the light and image, for nature does not well bear sudden changes. Therefore, when this humor is injured sight is destroyed. It is liquid in order that by means of its liquidity the light and image of the entering thing may become enlarged. This humor is situated in an opening in the uveal tunic, called the pupil of the eye. Inside there is a circular membrane which extends to the periphery of the crystalline lens, almost inclosing two humors, or, rather, inclosing the vitreous entirely and the crystalline almost entirely. This is called the "second tunic" because it arises from the second mater or pia mater. From this tunic three others arise at the same place. One is reflected inward between the crystalline and the vitreous, serving to separate them to a certain extent; it is called the retina, for it has innumerable veins, arteries, and nerves like the meshes of a net. At the same place arises another tunic called *aranea,* which overlies the crystalline humor and together with the retina forms a sphere. It is called aranea because it is like a spider's web; it is delicate in order not to impede the light from entering the crystalline humor, and it is placed like a separator between the crystalline and the albugineous humor. Outside this humor, but arising from the same place along with the *tunica secunda,* is still another tunic which forms an external spherical covering. This is called uvea, because it is perforated like a grape with its stem removed, and has the same shape and color. Its color is a mixture of black with a little white; if it were pure white it would dissipate the sight too much, and if it were pure black it would over-concentrate the sight. This tunic is rather dense; inside it is about as soft as the crystalline humor, and outside it is about as hard as the cornea; around its foramen it is pink. When the sight is weakened in its course and needs strengthening this membrane can be constricted like a purse, and when the sight suffers by diffusion of light, then the uvea can be dilated. In its foramen and filling its internal folds is the albugineous humor, and this is dilated and constricted with dilatation and constriction of the foramen of the uvea.

Again, from the outer membrane there arises another tunic outside the secunda which is called the sclerotic, because of its hardness. The cornea arises from the sclerotic and in connection with it forms a sphere. The cornea is clear and hard, resembling well-rubbed and polished horn. By its hardness it protects the inner structures; by its clearness it is

made pervious to light. In its center there is a broad circle having its opening in the middle of the uvea, and this circle is called the corona. The cornea is composed of four layers; if two or three are removed the fourth still remains, but when that is gone the cornea is destroyed. Finally, there is the conjunctiva, binding all the parts together. This arises from the nerve and not from the cerebral membranes. It is composed of white, moist, and soft flesh and of nerves and delicate veins. It has an opening in its center through which the corona is seen; this is the part of the uveal tunic which is called the pupil. On account of its depth it takes a different color than the albuginea, just as very deep water appears black, although it is really white. This tunic has seven pairs of muscles which produce all the movements of the eye, one moving the eye upward, another downward, two others moving it toward the two angles of the eye, one toward the domestic or lachrymal angle, another toward the sylvestrine angle. There are also two transverse muscles which move the eye circularly. Let this suffice for the structure of the eye.

(The following sections are omitted for lack of space: 27, The Ears; 28, The Nose; 29, The Mouth; 30, The Teeth; 31, The Uvula; 32, The Oesophagus; 33, Stomach; 34, Composition of the Stomach; 35, The Several Intestines. The treatment of these organs is not widely different from that of the earlier texts.)

36. The Liver

God made the liver to be the source of the blood and the origin of the veins. However, on this point Aristotle dissents from Galen, for Aristotle believes that the heart is the origin of the veins and proves that the liver is not the origin by the following reasons: First, the liver is composed of veins; since the components are prior to that which they compose, therefore the liver is not the beginning of the veins. Again, the liver is fleshy; the veins rather resemble fibrous tissue (*nervus*) and therefore must originate from fibers rather than from flesh. Again, the vital force flows from the heart to the other members; this force consists of warmth and moisture and so does the blood; therefore the blood comes from the heart. Galen says that it comes from the liver, for this reason: the blood is generated in the liver, therefore the liver is the source of the blood. Again, the waste-products of any substance surround the place of its origin; the urine is one waste of the blood and is contained in the bladder. Again, black biliary blood is another waste which is contained in the spleen. Again, another waste of the blood is contained in the gall-bladder, and finally, all these superfluities and the vessels which contain them are located about the liver; therefore the origin of the blood is in the liver, since its wastes are found surrounding the liver. On this point Avicenna remarks that there is nothing against the blood taking origin from the liver, although the heart is fleshy and

the veins are fibrous, for coral is found growing in the mud. It can also be said that both the heart and the liver are sources of the blood, but the heart is the first and mediate source, furnishing the heat of the blood, and the liver is the immediate and proximate source.

The liver is hollowed on one side, bulging on the other; it is located under the diaphragm and mostly on the right side. It is hollow in order to receive the stomach within its concavity. It has many processes, some small and others large, which embrace the stomach like the fingers of a hand. (Members of good holding capacity must be like the palm of the hand.)

The outside of the liver is convex in conformity to the shape of the inside of the body, for the inside of a man's body is round and the liver is joined to the spine, to which its round shape fits it. It is located on the right side in order to receive directly the vivifying insufflation of the heart. From the lower concave part of the liver a vein passes out and divides into many branches, giving rise to the small veins called mesenterics, some of which enter the intestines and drain them; others enter the stomach and there terminate, receiving from the stomach the better and subtler portions of its contents. The above-mentioned vein also branches in another direction and spreads throughout the whole substance of the liver. On the convex side of the liver these branches unite again to form a great vein, called *vena kilis,* which passes to the heart itself. In the concavity of the liver the *lactea* also ramifies, because there is a kind of milky humor coming from the intestines and the stomach.

37. Organs Accessory to the Liver

God created separate vessels for each of the superfluities of the blood because they perform various natural functions. In the second digestion three kinds of wastes depart from the blood: first a foamy, warm, and dry substance which is called bile, then an excretion which is called black bile, and finally a watery material tinged with blood, which is called phlegm. This also enters the bladder and is then called urine. The natural wastes have two sacs or canals, the larger of which is the urinary bladder, the smaller the gall-bladder. The gall-bladder is suspended in the concave part of the liver, that is, at the point of origin of the blood. It is connected with the liver and has three ducts. The first carries bile to the fundus of the stomach to aid in digestion. The second duct passes to the intestines and to the jejunum by way of several branches, carrying bile for the cleansing of the intestine. If the gall-bladder becomes obstructed severe pains occur in the intestines, for the bile is then irritant and pungent and stimulates the intestine to expel it. The third duct goes to the liver itself, and by this the gall-bladder draws off the warmer substances from the liver for its own nourishment, for it is warm and dry of complexion. This little sac possesses a neck in

which longitudinal fibers predominate, conferring strong attractive power; it also contains latitudinal fibers, serving for expulsion, and transverse fibers for retention.

The spleen is also a special organ of excretion. This is located between two warm members, the heart and the liver, in order that by its potential frigidity it may induce moderate temperatures in times of danger. It is of black-biliary complexion. It has two ducts. The first of these is directed to the orifice of the stomach, transmitting black bile to provoke the appetite. For this reason obstruction of the spleen causes distaste for food, but an over-free passage of black bile causes bulimia or excessive appetite. The second duct of the spleen passes to the liver, and through this the spleen draws off black-biliary matter for its own nourishment. The spleen has a somewhat oblong shape like the tongue, girdling the stomach. At one end it is joined to the liver in order to draw off black bile; for this reason the stomach becomes involved in disease of the spleen because an insufficient amount of black bile is transmitted to it; the liver in turn is chilled by retention of the black bile and thus arises disorder of the second digestion. The spleen is composed of coarse flesh and hard black bile; it is spongy and porous in order to absorb black bile for its own nutriment and to generate black bile from the blood and carry it through the organs. It is not necessary for all of this waste substance to be dispersed through the members, but it is necessary that it be withdrawn from the blood and deposited in one place.

38. The Strainers

God created two strainers by which the watery waste material is drawn off in order to prevent it from corrupting the blood. These are called kidneys, and they are two in number, because if there were only one it would have to be very large to receive so great an amount of watery waste material and thus it would interfere with neighboring organs. There is another reason why they are doubled, namely, if one of them is prevented from receiving the waste products the other will take a greater quantity. One is situated on the right side, the other directly opposite on the left. The one which is on the right is joined by its upper pole to the liver; that which is on the left is attached to the spleen. The kidneys are formed of solid substance for several reasons; first, in order that much may be condensed in a small space; again, by their solidity they resist humors, as, for instance, the pungent and destructive bile which comes from the stomach to the kidneys; and finally, to condense the blood and waste products by their hardness and solidity, like two ligatures pressing upon their ducts, thus refining the blood for their own nourishment by expressing the water. The separation of water from the blood occurs in three places, first, in the dome of the liver; second, in the vena cava, by which the watery material with the first blood, as

it were the washings of the flesh, is transmitted to the kidneys themselves, in which the second separation takes place; the third separation is carried on in the bladder. If the ducts of the kidneys are opened the blood flows into the bladder and passes off with the urine. The kidneys have two orifices, one superior, by which they drain the liver through certain canals, another inferior, through which they discharge into the bladder; and there is also a certain artery passing from the heart through the middle of the liver, bearing spirits or life to the kidneys. Certain veins also pass from the liver to the kidneys, bearing the nutriment of the blood to the outer parts of the kidneys; the kidneys have no veins inside them, but are nourished by the blood which they draw through the canals with the watery waste products. The kidneys are attached to some of the vertebrae, from which they derive a sensitive external covering. On the inner side they are slightly hollow, on the outer side rounded and nodular, having certain accessory orifices. They are surrounded by fat, for a reason which is assigned elsewhere.

(I omit 39, Urinary Bladder, and the latter part of 40, Penis.)

40. The Uterus

God created the uterus to be the instrument and the place of generation in women. Its neck is to be compared with the penis, and its internal cavity to the *oschium* or scrotal pouch; and it bears the same relation to the male generative organ as a seal bears to its impression in wax. The female organ is inverted, or turned inward; the male is everted or turned outward. The neck of the uterus has pouch-like membranes and folds, resembling the neck of the bladder, so that it may be dilated and constricted according to necessity. Before pregnancy the os uteri is constricted; its folds resemble a rose before the petals are expanded, and the canal is so tightly closed that there is passage for the urine only. At the first menstruation the neck of the uterus is dilated, certain veins in its right side are lacerated, and the blood flows. The os uteri is doubled, having an outer orifice where the neck of the uterus ends, and an inner orifice where it begins. At the time of conception it is closed so tightly that not even a needle can pass it; nature has arranged this to prevent harmful substances from entering after conception. At the time of parturition the neck of the uterus is dilated until it is as large as the interior of the uterus, like a rose when it is fully expanded.

Inside, at the middle of the uterus, there are two processes projecting into it, like two horns or nipples, to which two foetuses adhere, a male on the right side, a female on the left. Just as nature has prepared two breasts as external organs of nutrition, so are there two internal organs of attachment. Some mistakenly say that there are five cells in the uterus and some say seven, because a corresponding number of foetuses can be carried in the uterus at once; but it must be said that even as

many pears may be seen hanging from one tree, by which they are nourished, so may several foetuses adhere at once to one process in the uterus, from which they all take nutriment. On account of the fact that one of these two processes is connected with the right nipple, the other with the left, Hippocrates says that if the right breast shrinks a male foetus will be aborted.

The uterus is situated between the rectum and the bladder, the rectum serving as the cushion upon which it rests; in some women the neck of the uterus is longer, more slender, more tortuous, coarser, and straighter than in others, just as in some men the penis is more slender, longer, and more curved. The uterus is composed of two layers, of which the outer is more fleshy, the inner somewhat more nervous, so that it may be more or less sensitive but not to a great degree, for if the uterus were too sensitive child-birth would be over-painful. The outer layer is dry in order to preserve natural heat; the interior is ligamentous, that is, composed of all kinds of fibers, longitudinal, latitudinal, and transverse. The uterus is strongly attached on its posterior side to the spine by two ligaments. Its ligaments descend also to the knees and from the knees to the feet; above it is bound to the diaphragm by ligaments which ascend to the nipples and to the eyes. Near the os uteri there are two *iactores* resembling eggs or testicles, which are somewhat broader than the testicles of the male, and which are slightly elongated. They are broader in order to diffuse moisture and oblong on account of their heat. Nature made them twin organs in order that they should be the place of generation of the sperm itself, from which the substance of the human body arises. The female organs from which the sperm or substance of the sperm is derived are antecedent and consequential. The antecedent vessels are certain veins which proceed from the brain to the testicles, carrying whitened blood which had served as nutriment for the brain; the testicles make use of this blood as nourishment by means of their own attractive power. The residuum of this nutriment is transmitted to the consequential seminal vessels in the penis and through that organ into the uterus to generate the foetus. The male spermatic duct is narrow, long, and curved in order that the sperm may be thinned and refined during its long passage; but in women the sperm does not require to be thinned, since it needs to be coarser and moister than the male sperm which is to act upon it. For this reason the passage of the female sperm from the testicles to the uterus is short, and the sperm enters the uterus at once at the lower part of the uterus on each side and not through the os itself. For this reason it does not unite with the male sperm until both reach the uterus.

Below the internal os there is another opening, that of the bladder, which enters the neck of the uterus, and thus the urine is discharged by the same channel through which the sperm enters.

The male and female sperms mingle in the uterus, and the male sperm acts upon the female, for the male sperm naturally tends to impress the form of that from which it comes, and the female sperm tends to receive form. The sperm acts upon the female sperm, or (as others say) upon the menstrual blood, and causes bubbling like yeast in dough. Galen thinks, however, that each acts upon the other, and is acted upon by the other; at any rate, the two kinds of sperm are mixed and froth is formed in them in which are the three spirits, spiritual, vital, and animal, each conferring its own kind of movement and each tending to generate its appropriate material, the vital spirit generating the heart, the natural spirit generating the liver, and the animal spirit generating the brain. Thus, as the frothing reaches into the depths of the sperm, certain vesicles are formed in its midst by the action of the three spirits, an upper and a lower vesicle and a third beside the lower. From the first vesicle the heart is formed; from the second, which is above, the brain is formed, and from the third the liver is formed; but on this point there is the greatest disagreement between the authors, for Hippocrates says that the brain is created first, pointing out that the chick's head is the first thing to appear in the egg. Isaac appears to agree, since he compares man to an inverted tree with the brain as its root. Others declare that the liver is created first, since its action is needed before the others, and it must be created first if Nature proceeds in an orderly way. For this same reason Aristotle says that the heart is created first because its function is the first to be needed; for there can be no nourishment without life; life appears first in the heart and therefore the heart is created first.

The external parts are created from these three members by the powerful action of Nature. A connection is formed attaching the foetus to one of the nipple-like processes, by which menstrual substance is transmitted to the foetus, so that the members which are at first white become red. Although this connection is formed after the other parts, yet it is the first to be perfected.

In the first 7 days we have the frothy material and the three vesicles which form the three principal members; during the next 3 days, the internal outlines and beginnings of the other organs appear. During the first 6 days nothing is drawn from the uterus, because little or nothing of the spermatic material is lost, and if it were lost there would be no use restoring it. During the next 6 days the ramifications of the veins and arteries are developed by froth and spirits penetrating outward. During 12 days the blood makes it way through all parts and the fleshy members are formed, as we see in aborted foetuses. During the same time the neck is divided from the brain by means of the spine. During the next 20 days the membranes become distinct, the shoulders from the neck, the neck from the head, the thighs from the buttocks and so on. These processes require about 35 days, the total time varying

by one or more days, from a minimum of 30 to a maximum of 35. This diversity is due to the fact that the heat is more intense in some than in others, and the material of variable adaptability; the female body is formed more slowly than the male. The time of movement, that is, the time required for the appearance of voluntary motion, is twice the time of formation, the time of birth is thrice the time of movement. Because of the variation of the time of formation, the time of birth is also variable; some births occur in the seventh month, some in the eighth, and some in the ninth. Everything which has been said about the time of formation has been gained by observation of abortions at different times, in which the successive stages of formation appeared to the view of the ancient physicians.

In some materials the heat is greater than in others, and since this penetrates into the depths, leaving the extremities and external parts of the embryo, the latter become covered by an external layer, as eggs, for instance, are surrounded by a very thin membrane as well as by a hard shell. In the same way some trees are covered by three layers of bark, and certain fruits possess two or three coats; and thus the foetus in the maternal uterus is surrounded by three membranes. The first of these, lying next the foetus, is the thinnest, and is called *camissia pueri,* or *profundatio sudoris,* since this layer receives the sweat or waxy excretion. Between this membrane and the next the second excretion is received, namely, the urine, for after the urine is excreted by the kidneys it does not enter the bladder, but passes by way of a certain duct to the umbilicus, where it leaves the child and enters the two membranes, where it remains until at the time of birth it is expelled with the child. Its retention serves to soften and moisten the uterus and thus to enlarge it to permit the exit of the child, a thing which is done more easily by moisture than by dryness. The innermost membrane is thinner than the others and is composed of arteries and veins through which blood is carried to nourish the foetus, venous blood to the liver, and arterial blood to the heart; this tunic is like a net. The first excretion is not found in the foetus, because nothing enters the mouth and therefore there is nothing in the stomach or intestines to be excreted, for its nourishment comes through the umbilicus in the menstrual blood which is transmitted to the liver.

The foetus is covered by these three membranes not only for the reasons which we have mentioned, but also that it may adhere firmly to the uterus, for one single attachment by the umbilicus is not sufficient and the foetus needs to be attached in many places by these membranes. The position of the foetus and of its members is determined by its natural joints and folds; its two hands are upon its knees with the arms extended upon the two sides, the face upon the hands, and the nose between the knees; the knees bent, and the feet touching.

As time goes on and as the foetus grows and increases, it begins to move actively and vigorously and tends to make exit. There are three reasons for this, of which the first is the restriction of space in the maternal uterus; lack of nutriment is the second cause, for that which is transmitted from the uterus does not suffice; the third cause is the restriction of inspiration and expiration, the scarcity of air, and the warmth of that air which is breathed.

At the time of birth the foetus turns itself and leaves the uterus with the head down and the extremities above, so that the head by its thickness and weight makes room for the other members which follow it. When the feet come first there is danger that the arms may be broken; when one foot comes first there is danger of breaking the other foot; and when one arm comes first there is danger of breaking the other arm, and so on with the other members. The cotyledons are broken and the blood is discharged with the watery fluid which was retained within the membranes to soften and moisten the uterus. The uterus, in spite of so great dilatation, quickly shrinks to its proper and original size.

41. The Utility of the Heart

(A long paragraph on the heart, lungs, diaphragm, and brain, more or less repetitive. I translate only the following subsection on the brain.)

The brain is divided into three substances, the covering, the marrow, and the ventricles filled with spirits which form the source of the nerves which arise from the brain. The brain is cold, soft, and moist; it is cold that it may not be inflamed by vaporous fumes ascending from the stomach nor by the motion of the sensory nerves, nor by the operations of sensation, imagination, and cogitation, and that it may, on the other hand, moderate by its coolness the heat of the ascending vital spirits. It is soft and moist in order to receive sensory impressions and also that it may serve as nutriment for the nerves, which themselves are soft at first, gradually hardening in their course. The nerves are delicate, loosely put together, and flexible; they are soft to receive spirits, loosely put together for the sake of easy and swift motion, flexible that they may pass easily into all the members. The brain is softer and moister in its anterior part on account of the sensory nerves arising there, which have to be softer than the motor nerves. In the posterior part it is firmer on account of the motor nerves arising there, which have to be firmer than the sensory nerves, and also because that part is a storehouse of memory and a repository of images. The brain is divided laterally into two parts, and thus is a double member like many others; if, perchance, one side is injured the other still carries on its function. The posterior part of the brain descends with its membranes into the spinal cavity, whence nerves, arising on each side, pass into neighboring parts of the body.

42. The Operations Proceeding from the Mind

(This section consists, in spite of its title, of brief notes on various tissues and organs, i. e., cartilage, nerves, ligaments, etc., concluding with the following account of the heart.)

Among all the organs of the body seven are royal and distinguished, having much subtlety according to the seven orders of the planets and their different centers. These members are the seats of animate and intelligent spirits. They are the brain, the heart, the liver, and the stomach, with the kidneys, bladder, and testes. According to some there are three principal organs, the brain, the heart, and the liver, the testes not being principal because they are not essential to the individual but to the species. According to others, only two are principal, the brain, which is the source of sensation and motion, and the heart, which is the source of life. Therefore let us see what is the substance of the heart, what its composition, its complexion, its form, its situation, and its motion. Its substance is thick, hard, and solid flesh which is generated from black bile. In weight it is comparable to stones like coral, pearl and jacinth, which have hard substance, for there is no part of the human body which weighs as much proportionately as the heart. From this it follows that it is dry and cold of complexion, at least according to Aristotle; but according to Galen it is hot and dry of complexion because it contains in itself the heat of the whole body or the heated material, namely, the blood and vital spirits which it forces throughout the body. The heart is composed of various similar substances—of hard flesh, as we have said, and of cartilage, which is found externally at the base, not differing much from bone, and of strong and tough membranes surrounding the heart itself but not touching it anywhere except upon the two ventricles and upon the apex, so that it may dilate and constrict according to necessity. Because of this diversity of its parts it resembles all members rather than any one member, being itself primal and universal. Moreover, it has the form of a pine-cone, somewhat rounded, for such a form is less likely to collect harmful superfluities. It is broad above in order that the vein and artery may have a wide space from which to take origin. Below it is conical and constricted in order that it may touch the thorax but slightly, and thus may not readily be damaged. Internally its form is rugous when constricted, smooth when dilated. It has three internal cavities, right, left, and middle. The right is the lowest and is turned toward the liver, drawing thence what is needful for its nourishment. The left is smaller than the right; it is higher and is turned toward the lung, drawing thence the air which it needs. Between these cavities is a central opening called fovëa by the authors, situated in the fundus of the heart, in which the blood is mixed with air, making vital spirits which the heart forces through all the members of the body.

Aristotle lays down three proofs that the heart is the beginning of all the veins and arteries in the body. The first is that the heart is the source of heat, but the heat is the cause of digestion and therefore the heart is the source of the digestion of food, and therefore it is the source of the organs in which digestion is performed. These are the veins and arteries, and thus the heart is their first and ultimate source. Galen denies this, saying that the vena cava goes to the heart bearing nutriment from the liver, and since veins pass from the stomach and the three intestines to the liver, therefore neither the liver nor the heart is the source of the veins. It is said against this opinion of Galen that anything which takes origin from another will resemble its source; the veins arise from the liver and therefore resemble it, for they are cold and dry of complexion and therefore the liver is phlegmatic. Moreover, the liver is composed of veins and arteries, but the components of anything must precede it, and therefore the liver is not the source of the vessels; again, all the members, except the heart, are penetrated by veins and arteries, which carry heat to all parts of the body, including the liver, spleen, kidneys, testicles, stomach, the lung, the diaphragm, and likewise the brain, for veins and arteries run from the heart to the front of the brain, from the front to the middle, from the middle to the back, and thus even to the nerves which arise from the brain. I say that the arteries bearing vital spirits to the nerves are supplied by the heart because the brain is penetrated by vessels, but the heart is not penetrated, and therefore the heart is the source of the arteries. On the other hand, it is said that beneath the entire substance of the heart veins and arteries may be found, and thus the heart is penetrated by vessels, like all the other members. Solution: Both the veins and arteries arise from the root of the heart, and as they leave it they penetrate its whole substance; therefore arteries and veins coming to the left auricle at its outlet are turned back into its external substance; but no other veins nor arteries taking origin from any other source are found to enter it.

Again, just as from the *anima,* which is simple in essence, all the bodily forces flow to all the parts to perform all the operations of the *anima,* so from the cone, the base, and the apex of the heart, the encircling veins and arteries pass to all parts of the body, carrying heat. Thus if the *anima* is the source of the bodily forces, the heart is the source of the veins and arteries. This we concede.

It is said (according to Aristotle) that anything which takes origin from something else will resemble that from which it arises; therefore the veins do not arise from the liver. Against this Avicenna remarks that coral, which is an extremely hard tree, takes origin from mud and soft material at the bottom of the sea. Solution: Aristotle is thinking, when he speaks, of the permanent substance, but Avicenna is thinking of material in passage. Aristotle says that the heart presides over the

resolution of life and also that the animal perceives nothing but sensation and motion; but according to Galen the brain is the center of sensation and motion and the liver the seat of digestion. Against this it may be said that the heart is either the source of all things or it is not; if it is the universal source, then sensation and motion are made by it and also digestion is there begun; if not, on the contrary, it must have some other function than that by which sensation and motion are produced and some other than that by which digestion is carried on. But if so, what is that function? and what is the use of the pulse? If the heart is the universal beginning of all the members, its function must be universal, and therefore the pulse would be created in all members, which is false, for the pulse is in the arteries alone.

Again, it is said that all moral virtues are located in the heart, and this is indicated by the fact that the varied complexion of the heart is accompanied by variation of the moral virtues. The moral virtues are internal characteristics of the animal, but motor and sensory functions are external characteristics, and therefore the heart is the source of the latter.

Again, the motor and sensory functions being located in the heart, it follows that the heart is also the seat of the vegetative force, and therefore the heart must be the seat of growth. Galen, however, lays down two reasons to prove that the liver is the seat of digestion. First, the blood is first found in the liver and therefore the liver is the seat of digestion; second, at each stage of digestion the excess substances are expelled to their appropriate receptacles, namely, bile to the gall-bladder, black bile to the spleen, urine to the urinary bladder; but these receptacles surround the liver and not the heart. Therefore the liver is the first and immediate seat of digestion and the heart the intermediate seat; and thus we explain the differences between Galen and Aristotle.

43. The Nerves

(The first part of this section is copied, as described on page 39, from Rhazes and Avicenna; the latter part is a list of the veins to be phlebotomized for various ailments.)

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(References in *italics* are to the translations of the anatomical texts).